MIGRATION AND LEPROSY IN BRAZIL

INAUGURALDISSERTATION

Zur

Erlangung der Würde eines Doktors in Philosophie

vorgelegt der
Philosophisch-Naturwissenschaftlichen Fakultät
der Universität Basel

Von

Christine Murto

aus

Washington, DC USA

Basel, 2014

Genehmigt von der Philosophisch-Naturwissenschaftlichen Fakultät
auf Antrag von

Dr. Charles Kaplan und Prof. Marcel Tanner

Basel, den 18 September 2012

Prof. Dr. Jorg Schibler
Dekan der Philosophisch-Naturwissenschaftlichen Fakultät

Summary

Background: Leprosy is among the Neglected Tropical Diseases (NTDs), and is an endemic public health problem in high-risk clusters throughout Brazil. Leprosy is caused by the intracellular bacteria *Mycobacterium leprae*, affecting the skin and peripheral nerve function. The disease can cause significant disabilities through nerve damage and secondary infection. Nasal mucosa is considered the primary transmission site due to the presence of active bacilli. However, transmission continues to remain unclear. Environmental risk has also been considered, as leprosy has been found in local water and soil sources in endemic areas, and leprosy mycobacteria can survive outside of the body for up to 60 days.

While household contact with multibacillary cases (>5 lesions) remains the primary risk factor for leprosy, genetic relationships are thought to be a risk independent of physical contact. Socioeconomic factors and conditions of poverty, such as inadequate housing and sanitation, poor nutrition and household density, also related to leprosy contact proximity, have been found to be risk factors in Brazil and other countries. These factors can increase the risk for both leprosy transmission and onset of leprosy symptoms, particularly when factors associated with poverty compromise immune response.

Migration is considered to be a social determinant of NTDs, including leprosy. Social disparities and conditions associated with migration place non-immune migrants at risk for infection when exposed to disease.

Migration can additionally influence the distribution of disease through movement of baciliferous individuals into previously non-endemic areas. Thus, leprosy control may be hindered by increased transmission and distribution due to migration. In Brazil, leprosy new case incidence at 1.77/10.000 inhabitants nationally remains above the World Health Organization elimination goal of <1 case per 10,000, with some states exceeding 5.0 cases per 10,000 in the North, Central West and Northeast areas of the country.

Objectives: The overarching goal of this PhD research was to support the Brazilian Leprosy Control program to improve targeted service delivery towards migrating populations, by investigating social, behavioral and other factors associated with migration and leprosy in the Northeast of Brazil.

There were four primary objectives: 1) to identify motives and determinants for residence change after leprosy diagnosis; 2) to describe factors influencing migration before and after diagnosis among those infected with leprosy; 3) to identify social, environmental and behavioral factors associated

with migration in individuals newly diagnosed with leprosy, compared to an uninfected reference population; and 4) to determine patterns of migration and migration risks associated with leprosy infection among past five year migrants.

Methods: This study entailed two comprehensive population-based epidemiological studies conducted in areas identified by the Brazilian Ministry of Health as highly endemic clusters for leprosy transmission, in the states of Tocantins and Maranhão in the Northeast of Brazil. In four municipalities of Maranhão, individuals newly diagnosed with leprosy in 2009 and 2010 and an uninfected reference population matched by age, sex and geographic location were interviewed. In Tocantins, individuals newly diagnosed with leprosy in 79 municipalities between 2006 and 2008 were interviewed, using structured questionnaires.

Results: Leprosy was found to be associated with migration, and more severe multibacillary leprosy was prominent among migrants. Among past five year migrants, leprosy was associated with household and family leprosy contact, past five year alcohol consumption and poverty. Many of the factors associated with leprosy infection were also associated with migration among those with leprosy. Migration was largely facilitated through familial relationships and was associated with poverty and indicators of poverty, and past five year alcohol consumption. These factors were unique to those with leprosy in comparison to an uninfected reference population. Family separation was also associated with migration, although this was significant among all migrants and not only those with leprosy. Limited access to health services was a barrier that was associated with migration among those with leprosy, although the majority of residence change after diagnosis was for lifestyle changes and not for the purpose of seeking medical care.

Conclusion: The relationship between internal migration and leprosy, and social and behavioral aspects influencing migration among those with leprosy has been investigated. Leprosy was associated with migration, and further investigation identified social and behavioral factors unique to migrants such as poverty, alcohol consumption, as well as lifestyle stressor separation from family and friends' which was associated with both migration and leprosy infection. Additionally, late diagnosis is evident in migrants with multibacillary leprosy. Future research should assess the role of alcohol consumption and life stressors in leprosy transmission and symptom onset.

National control efforts should take into account factors which distinguish migrants from non-migrant and uninfected populations. Based on these, interventions targeting risk factors, i.e.

substance abuse and stress in affected populations, could help to reduce leprosy transmission. The extension of clinic hours and health service availability that meet the needs of migrating populations is recommended in order to increase early leprosy diagnosis and reduce disability.

Zusammenfassung

Hintergrund: Lepra gehört zu den vernachlässigten Tropenkrankheiten (NTDs), und ist ein Gesundheitsproblem in endemischen Hochrisikogebieten Brasiliens. Lepra wird durch das intrazelluläre Bakterium *Mycobacterium leprae* verursacht, dessen Zielorgane die Haut und der periphere Nerv sind. Durch Nervenschäden und Sekundärinfektionen kann die Erkrankung erhebliche Behinderungen beim Betroffenen verursachen. Die Nasenschleimhaut gilt als die primäre Übertragungsstelle, da hier aktive Lepra-Bazillen nachgewiesen werden können. Trotzdem bleibt die genaue Krankheitsübertragung unklar. Die Umwelt als möglicher Risiko- oder Übertragungsfaktor wird auch in Erwägung gezogen, weil Leprabakterien in Wasser und Böden in endemischen Gebieten gefunden wurden und erwiesen ist, dass das *Mycobacterium* bis zu 60 Tagen ausserhalb des Körpers überleben kann.

Physische Nähe zu einer multibazillären Person (>5 Läsionen), insbesondere wenn im gleichen Haushalt lebend, gilt als primärer Risikofaktor für Lepra. Zudem besteht die Vermutung, dass genetische Faktoren eine Rolle spielen, unabhängig von direktem Körperkontakt. Soziale und ökonomische Faktoren und Armutsindikatoren wie zum Beipiel schlechte Wohnbedingungen, unzureichende sanitäre Anlagen, mangelhafte Ernährung und eine hohe Haushaltsdichte, welche auch mit Lepra-Kontaktnähe assoziiert sind, wurden in Brasilien und anderen Ländern als Risikofaktoren identifiziert. Diese Faktoren erhöhen sowohl das Risiko einer Übertragung und auch die Wahrscheinlichkeit eines Ausbruch der Lepra-Symptome, insbesondere wenn Armutsfaktoren zusätzlich die Immunreaktion gefährden.

Migration gilt als sozialer Einflussfaktor für NTDs, einschließlich Lepra. Soziale Ungleichheiten und Bedingungen welche mit Migration assoziiert sind setzen nicht-immune Migranten einem Infektionsrisiko aus.

Zusätzlich kann das Verteilungsmuster der Lepra durch menschliche Migration beeinflusst werden, zum Beispiel wenn bazilläre Individuen in zuvor nicht-endemische Gebiete migrieren. Eine darausfolgende, erhöhte Übertragungsrate und Verteilungsfläche der Krankheit kann die Kontrolle der Lepra weiter erschweren. In Brasilien ist die durchschnittliche Inzidenz der Lepra 1.77 Fälle pro 10‘000 Einwohner. Diese Inzidenz liegt über dem Richtwert der Weltgesundheitsorganisation zur Eliminierung von Lepra (1.00 Fälle pro 10‘000 Einwohner). Einige Staaten in Nord-, Zentralwest-, und Nordost-Brasilien verzeichnen sogar mehr als 5.00 Fälle pro 10‘000 Einwohner.

Ziele: Das übergeordnete Ziel dieser Doktorarbeit war es, das brasilianische Lepra-Kontrollprogramm zu unterstützen die gezielte Leistungserbringung gegenüber der migrierenden Bevölkerung zu

verbessern. Dafür wurden im Nordosten Brasiliens Verhaltens-, soziale, und andere Faktoren untersucht, die möglicherweise mit Lepra und Migration assoziiert sind.

Vier Hauptziele wurden definiert: 1) Die Identifikation der Motive und Determinanten für einen Aufenthaltswechsel nach einer Lepradiagnose; 2) Die Beschreibung der Faktoren, die eine Migration bei Menschen mit Lepra beeinflussen, sowohl vor wie nach Diagnosestellung; 3) Die Identifikation von sozialen, Umwelt-, und Verhaltensfaktoren welche mit Migration assoziiert sind bei neu identifizieren Lepraerkrankten verglichen mit einer nicht-infizierten Referenzpopulation; und 4) Die Identifikation von Migrationsmustern und -risiken welche mit einer Leprainfektion assoziiert sind in Individuen mit Migrationshintergund in den letzen 5 Jahren.

Methoden: Diese Doktorarbeit beinhaltet zwei umfassende Bevölkerungs- Epidemiologischen studien in den Bundesstaaten Maranhão und Tocantins im Nordosten Brasiliens, in Gebieten die vom brasilianischen Gesundheitsministerium als hoch endemisch für Lepraübertragung klassifiziert wurden. In vier Gemeinden von Maranhão, wurden Personen interviewt bei denen zwischen 2009 und 2010 ein Lepra diagnostiziert wurden, und mit einer Referenzpopulation, deren Alter, Geschlecht und Habitat mit der Studienpopulation übereinstimmt, verglichen. In Tocantins wurden in 79 Gemeinden Lepra-Betroffene die zwischen 2006 und 2008 diagnostiziert wurden mittels strukturiertem Fragebogen interviewt.

Ergebnisse: Die Resultate zeigen, dass eine Leprainfektion und Migration assoziiert sind, und die schwerwiegendere, multibazilläre Lepra in der Migrationspopulation prävalent ist. In Individuen mit Migrationshintergrund in den letzen 5 Jahren war Lepra assoziiert mit Leprakontakt im Haushalt oder in der Familie, Alkoholkonsum in den letzen 5 Jahren und Armut. Viele der Faktoren welche mit einer Leprainfektion assoziiert waren, waren ebenfalls assoziiert mit Migration in Leprapatienten. Migration war zudem erleichtert bei familiären Beziehungen und war mit Armut, Armutsindikatoren, und Alkoholkonsum in den letzten 5 Jahren assoziiert. Diese Faktoren waren jedoch nur bei Lepraerkrankten signifikant assoziiert und nicht bei der nicht-infizierten Referenzpopulation. In allen Migranten war die Migration mit einer Familienseparation assoziiert. Diese signifikante Assoziation wurde in Leprainfizierten sowie Nichtinfizierten gefunden. Ein erschwerter Zugang zu Gesundheitsdienstleistungen war für lepraerkrankte Migranten mit einer Migration assoziiert. Der Habitatswechsel nach der Diagnose war aber eher mit einer Änderungen des Lebensstils verbunden und war nicht zum Zweck der Suche nach besserer medizinischer Versorgung.

Schlussfolgerungen: Die Beziehung zwischen interner Migration und Lepra wurde untersucht, ebenso Sozial- und Verhaltensaspekte, die eine Migration bei Menschen mit Lepra beeinflussen. Lepra war assoziiert mit Migration, und weitere Untersuchungen beschrieben Verhaltens- und soziale Faktoren die einzigartig für die Gruppe der Migranten waren. Dies waren Armut, Alkoholkonsum, sowie eine Trennung von Familie und Freunden. Letztere wurde sowohl mit Migration und als auch mit einer Leprainfektion assoziiert. Zusätzlich war eine späte Diagnose bei Migranten mit multibazillärer Lepra offenkundig. Zukünftige Forschung sollte die Rolle des Alkoholkonsums und anderen sozialen Stressfaktoren in der Lepraübertragung und beim Symptombeginn untersuchen.

Nationale Kontrollbemühungen sollten Faktoren berücksichtigen, die Migranten und Nicht-Migranten oder nicht-infizierte Populationen unterscheiden. Auf dieser Grundlage könnten Interventionen die auf Risikofaktoren, wie zum Beispiel Substanzmissbrauch und Stress, zielen, die Übertragung von Lepra reduzieren. Längere Öffnungszeiten von Kliniken und eine erleichterte Verfügbarkeit des Gesundheitswesens sind empfohlen um die Bedürfnisse der migrierenden Bevölkerung zu befriedigen. Dies kann eine frühere Lepradiagnose ermöglichen und leprainduzierte Behinderungen reduzieren.

Acknowledgements

My most heartfelt thanks to the many wonderful people who guided me along the PhD-path. I would like to thank Dr. Jorg Heukelbach at the Federal University of Ceará (UFC) for his guidance, direction, and knowledge of epidemiology, and for the introduction to public health in Brazil's interior; the entire MAPATOPI team of dedicated researchers in leprosy at UFC for the extraordinary camaraderie and friendship found along the interior roads and rivers of Maranhão; and to Prof. Dr. Charles Kaplan who provided invaluable support and mentorship that guided me through the PhD and many prior projects, and his enlightened insight in bridging social science and epidemiology.

Many thanks to all the colleagues, friends and professors at SwissTPH, in Basel and over the globe, with whom I've learned and shared. In particular, to Christine Mensch, PhD Coordinator, who is the sunshine for all PhD students at the institute, for her warmth, support and friendship; to Penelope Vounatsou for her patience and assistance through the statistical methods and Jan Hattendorf for his invaluable help with analysis and insight; to Esther Schelling for her most important support in the next phases from PhD onward; and a most special thanks to Professor Marcel Tanner for giving me this incredible opportunity, and for his continuous support in friendship, and pearls of wisdom and advisement through these three years, for which I will forever be grateful.

To my very dearest friends on land and sailing the oceans, thanks for being the wind at my back so I could follow the seas, and for always lightening the load with laughter.

Of course, to the very best family, thanks for keeping me in your hearts and staying in touch always, despite the distance. I'm especially grateful to my parents for their unconditional love; to my mom who showed me the value of community action and leadership, and the importance of equality and respect for everyone at an early age; and to my dad who taught me to live my life with integrity and honesty, and to make life a fun adventure regardless of the conditions. Finally, thanks to my sister, my life-long friend who I will forever treasure.

A most special and sincere thanks to all those with leprosy who shared their stories, through moments of tears and laughter, with whom this research would not be possible; and to those who have migrated, whose hopes and dreams have no borders.

Each friend represents a world in us, a world possibly not born until they arrive, and it is only by this meeting that a new world is born…Anais Nin March 1937

Table of Contents

Summary I
Zusammenfassung V
Acknowledgements IX
Table of Contents XI
List of Tables XIV
List of Figures XV
List of abbreviations XVI
1 Introduction 1
1.1 Epidemiological Context of Leprosy 1
1.1.1 Leprosy Infection 1
1.1.2 Leprosy in Brazil's Northeast and Northern Regions 3
1.2 Social Determinants of Health, Migration and NTDs 6
1.2.1 Social Determinants of Health and NTDs 6
1.2.2 Migration and NTDs 7
1.2.3 Migration in Brazil 8
1.3 Goals and Objectives 8
1.4 Study Sites 9
1.5 References 11
2 Motives and determinants for residence change after leprosy diagnosis, central Brazil† 17
2.1 Abstract 18
2.2 Introduction 19
2.3 Methods 20
2.3.1 Study Area 20
2.3.2 Study Design and Data Collection 20
2.3.3 Data Analysis 20
2.3.4 Ethics 21
2.4 Results 21
2.5 Discussion 22
2.6 Acknowledgments 26
2.7 References 27
3 Migration among individuals with leprosy: A population-based study in central Brazil† 31
3.1 Abstract 32
3.2 Introduction 33
3.3 Materials and Methods 34

3.3.1 Study Design and Data Collection 34
3.3.2 Study Area and Population 34
3.3.3 Data Collection 34
3.3.4 Data Analysis 35
3.3.5 Ethics 36
3.4 Results 36
3.4.1 Factors associated with migration in the five years before diagnosis 37
3.4.2 Factors associated with migration after diagnosis 38
3.5 Discussion 38
3.5.1 Key Demographics 39
3.5.2 Poverty 39
3.5.3 Migration, Leprosy and Healthcare Access 40
3.5.4 Limitations 41
3.6 Conclusions 42
3.7 Acknowledgments 42
3.8 References 44
Appendix Chapter 3 48
4 Factors Associated with Migration in Individuals Affected by Leprosy, Maranhão, Brazil: An Exploratory Cross-Sectional Study 55
4.1 Abstract 56
4.2 Introduction 57
4.3 Materials and Methods 59
4.3.1 Study Area 59
4.3.2 Study Design 60
4.3.3 Data Collection 61
4.3.4 Field Procedures and Survey Instruments 61
4.3.5 Data Analysis 62
4.3.6 Ethics 63
4.4 Results 63
4.4.1 Study population characteristics 63
4.4.2 Factors associated with migration in the past five years 64
4.4.3 Factors associated with circular migration five years before diagnosis 65
4.5 Discussion 65
4.6 Limitations 68
4.7 Conclusions 69
4.8 Acknowledgements 70
4.9 References 77

Appendix Chapter 4 80
5 Patterns of Migration and Migration Risks With Leprosy Infection in Maranhão, Brazil 89
5.1 Abstract 90
5.2 Introduction 91
5.3 Methods 92
5.3.1 Ethics Statement 92
5.3.2 Study area 93
5.3.3 Study design 93
5.3.4 Study sample 93
5.3.5 Data collection 94
5.4 Results 95
5.5 Discussion 97
5.6 Conclusion 101
5.7 Acknowledgements 102
5.8 References 106
6 Discussion 111
6.1 Social Determinant of health, health inequities and NTDs 111
6.2 Social Determinants of Migration and Leprosy 113
6.2.1 Poverty 115
6.2.2 Social Networks 117
6.2.3 Psychosocial and Behavioral Factors 118
6.2.4 Access to Health Services 119
6.3 Conclusions 119
6.4 References 121
Curriculum Vitae 125

List of Tables

Table 2.1: Motives/determinants for moving after leprosy diagnosis 22
Table 3.1: Adjusted Odds Ratios of factors significantly associated with before diagnosis migration 43
Table 3.2: Adjusted Odds Ratios of factors significantly associated with after diagnosis migration 43
Table 3A.1: Bivariate analysis of factors associated with migration before and after leprosy diagnosis 48
Table 4.1: Multivariate analysis of factors associated with migration after birth among migrants diagnosed with leprosy 71
Table 4.2: Multivariate analysis of factors associated with migration after birth among migrants in a clinically unapparent population 72
Table 4.3: Multivariate analysis of factors associated with past 5 year migration among migrants diagnosed with leprosy 73
Table 4.4: Multivariate analysis of factors associated with past 5 year migration among migrants in a clinically unapparent population 74
Table 4.5: Multivariate analysis of factors associated with past 5 year circular migration among migrants diagnosed with leprosy 75
Table 4.6: Multivariate analysis of factors associated with past 5 year circular migration among migrants in a clinically unapparent population 76
Table 4A.1: Bivariate analysis of factors associated with migration after birth 80
Table 4A.2: Bivariate analysis of factors associated with past 5 year migration 83
Table 4A.3: Bivariate analysis of factors associated with past 5 year circular migration 86
Table 5.1: Demographics and migration patterns of past 5-year migrant leprosy cases 103
Table 5.2: Crude (OR) and adjusted odds ratios (AOR) for the association of leprosy and five year migration 104
Table 5.3: Factors associated with leprosy diagnosis among past five year migrant cases 105

List of Figures

Figure 1.1: New case incidence by region 1990-2010 per 100,000 inhabitants by Region in Brazil .4
Figure 1.2: Spatial aggregation of leprosy cases in 10 major clusters in Brazil (2005-2007) 5
Figure 1.3: Ten most probable cluster of leprosy defined by using spatial scan statistics, Brazil, 2005-2007.....6
Figure 1.4: Study sites: Endemic clusters in the states of Tocantins and Maranhão 10
Figure 4.1: Map of Maranhão and four study sites 59
Figure 4.2: Study Design.....61
Figure 5.1: Locations of the 10 most probable leprosy clusters and municipal councils, Brazil, 2005–2007. 96
Figure 6.1 Overview of possible socioeconomic indicators to measure health inequities.....112
Figure 6.2 Leprosy and migration framework.....115

List of abbreviations

CAPES	Coordenação de Aperfeiçoamento de Pessoal de Nível Superior
CDC	Centers for Disease Control and Prevention
CNPq	Conselho Nacional de Desenvolvimento Científico e Tecnológico
CSDH	Commission on Social Determinants of Health
FUNCAP	Fundação Cearense de Apoio ao Desenvolvimento Científico e Tecnológico
IEC	Information, Education and Communication approach
IBGE	Instituto Brasileiro de Geografia e Estatística
ILEP	International Federation of Anti-Leprosy Associations
IOM	International Organization for Migration
MB	Multibacillary
MEKN	Measurement and Evidence Knowledge Network
MoH	Ministry of Health
NTDs	Neglected Tropical Diseases
PAHO	Pan American Health Organization
PB	Pauibacillary
PNAD	Pesquisa Nacional por Amostra de Domicílios
SDH	Social Determinants of Health
SINAN	Sistema de Informação de Agravos de Notificação
UNDP	United Nations Development Program
UNPF	United Nations Population Fund
WHO	World Health Organization

1 Introduction

1.1 Epidemiological Context of Leprosy

1.1.1 Leprosy Infection

Leprosy (Hansen's disease) is an infectious disease caused by *Mycobacterium leprae* that mainly affects the skin and peripheral nerves. Nasal mucosal lesions, and discharge therefrom, are considered the primary site of transmission, as bacilli are active in the nasal cavity (Pedley, 1973; Rees & McDougall, 1977). Nevertheless, mucosal transmission continues to be unclear and new research indicates the possibility of oral contact of *M. leprae* as an additional mode of transmission (Martinez et al., 2011). Presence of bacilli on intact skin surface lesions is rare, and is not thought to be a significant risk in transmission (Pedley, 1970).

There are also indications for indirect exposure to leprosy through soil and water (Matsuoka, Isumi, Budiawan, Nakata, & Saeki, 1999; Lavania, et al., 2008; Kerr-Pontes, et al., 2006). Viability for *M. leprae* to survive outside of the human body in differing conditions suggests that indirect contact could play a role in transmission, particularly in hot and humid climates. Research on bacilli outside of the body has determined the average time *M. leprae* can survive under varying conditions: at room temperature for 60 days; 3 hours per day of direct sunlight for 7 days; at 4 °C for 60 days; and at -70 °C for 28 days (Desikan & Sreevatsa, 1995).

Leprosy has two classifications, paucibacillary and multibacillary. Paucibacillary (PB) leprosy is characterized by up to five skin lesions, and is considered a less severe form of leprosy with low bacterial load. Multibacillary (MB) disease has more than five lesions, and often includes other symptoms such as nodules, plaque and thickened nerves. In Brazil, more than 40% of new cases are diagnosed as MB (WHO, 2011). The average incubation time is five years for PB and seven years or more for MB disease (WHO, 2009). Leprosy can also be more specifically diagnosed by clinical forms:

PB:

- Indeterminate: early onset with a single lesion that can progress into other more serious forms of leprosy
- Tuberculoid: A single lesion or area of hyperpigmentation with sensory loss that can progress into borderline or more severe forms of leprosy

MB:

- Borderline: numerous lesions of sensory loss, can include nodules and plaques
- Lepromatous: Most severe form of leprosy that involves multiple lesions, thickening of peripheral nerves and sometimes involves other organs

With a delay in diagnosis and specific therapy, there is a considerable potential for developing physical disabilities, progressing to visible deformities over time. The deformities can lead to reduced capacity for work, limited social life and psychological problems, and increase the stigma and prejudice towards those with the disease (Oliveira, Mendes, Tardin, Cunha, & Arruda, 2003; Chaturvedi, Singh, & Gupta, 2005; Tsutsumi, et al., 2007). Leprosy is graded by the extent of disability caused by the disease with grade-0 as no sensory loss to grade-2 with visible impairments.

The current global strategy through 2015 is to reduce grade-2 disability at diagnosis through early diagnosis and treatment, which is expected to also reduce new case incidence and leprosy transmission (WHO, 2009).

Leprosy is associated with poverty and is considered a Neglected Tropical Disease (NTD) (Kumar, Yadav, Girdhar, & Girdhar, 2005; Hotez, Bottazi, Franco-Paredes, Ault, & Periago, 2008; Mathers, Ezzati, & Lopez, 2007; Kerr-Pontes, et al., 2006). Socioeconomic factors associated with poverty such as food shortage, inadequate housing, high household density and inadequate sanitation can reduce individual immunity and increase the risk for onset of latent leprosy symptomology (Kerr-Pontes, et al., 2006; PAHO, 2007). The primary risk factor for leprosy transmission is household contact (Fischer, De Vlas, Meima, Habbema, & Richardus, 2010; Fine, et al., 1997; Sales, et al., 2011; van Beers, Hatta, & Klatser, 1999; Moet, Pahan, Schuring, Oskam, & Richardus, 2006; Durães, Guedes, Cunha, Magnanini, & Oliveira, 2010), and household density can influence the intensity of exposure. Research has found that MB contact increases risk for transmission compared to PB leprosy (Moet, et al, 2006; Fine, et al., 1997; Sales, et al., 2011; van Beers et al., 1999).

The resolution to eliminate leprosy as a public health problem was introduced at the 44th World Health Assembly in 1991. The goal of elimination was to reduce leprosy prevalence to one case per 10,000. (WHO, 1991). In 2000, while this goal was realized globally, endemic regions in the world continue to exist. At the end of 2010, the number of new leprosy cases detected worldwide was approximately 228, 474 (WHO, 2011).

Among the 16 countries where leprosy remains today as a public health problem, only three account for more than 78% of new cases detected worldwide: India (126,800), Brazil (34,894), and Indonesia

(17, 012) (WHO, 2011). Additionally, since 2006, the number of relapsed cases of leprosy has increased each year (WHO, 2010). Thus, despite advances in its control in recent years, the elimination of leprosy is a complex task that requires a multidisciplinary approach to control (Lockwood & Suneetha, 2005).

1.1.2 Leprosy in Brazil's Northeast and Northern Regions

In Brazil, leprosy control is being undertaken at national and local levels in an effort to reduce new case incidence and disability associated with advanced disease expression. In 2011, the national new case incidence for leprosy was 1.77 per 10,000 inhabitants (Brazil MoH, 2012), clearly above the < 1/10,000 elimination goal.

Figure 1.1 indicates new case incidence of leprosy in Brazil and by region. The disease is spread throughout the country, with predominance in the North with a new case incidence of 4.27/10,000 in 2011, 4.04/10,000 in the Central West and 2.61/10,000 in the Northeast (Brazil MoH, 2012). Together the North and Northeast regions were responsible 61.3% of total cases in the country in 2011 (Brazil MoH, 2012). That same year, the country maintained an average incidence for under 15 years of age of 0.52 new cases per 10,000 inhabitants (2420 new cases) (Brazil MoH, 2012). This signals recent dynamic transmission of disease through active sources of infection. The Northeast region was responsible for 48.2% of these cases while in the north 27.7%, for a total of 75.9% of cases in this age group in Brazil (Brazil MoH, 2012).

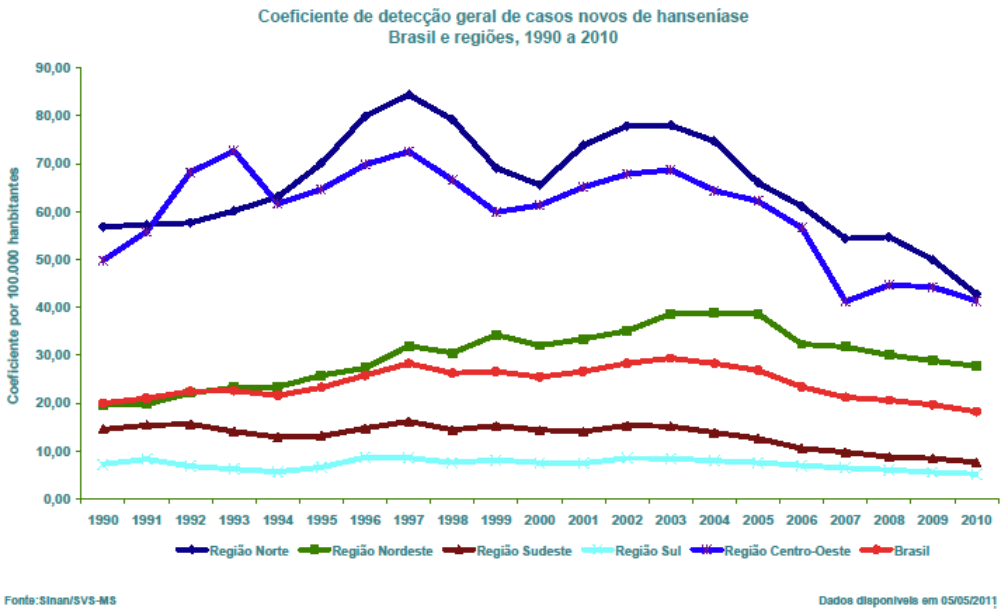


Figure 1.1: New case incidence by region 1990-2010 per 100,000 inhabitants by Region in Brazil (Brazil MoH, 2011)

In general, due to the high incidence rate of new cases, the North and Northeast are considered endemic for leprosy. Many states exceed the 5.0 per 10,000 inhabitants qualifying them as hyper endemic. New case incidence was highest in the Central West state of Mato Grosso (8.5/10,000), Northern states of Tocantins (7.1./10,000), Rondonia (5.4/10,000) and Pará (5.1/10,000), and Northeastern state of Maranhão (5.6/10,000).

1.1.3 Leprosy cases by cluster in Brazil

Spatial analysis through the Brazilian National Hansen's Disease Control Program of the Federal Ministry of Health Secretary of Health Surveillance determined 10 major clusters to detect areas at the municipal level in three regions where leprosy is a significant public health problem (Figure 1.2, Brazil, 2008). Spatial scan statistics were used for cases detected between 2005 and 2007.

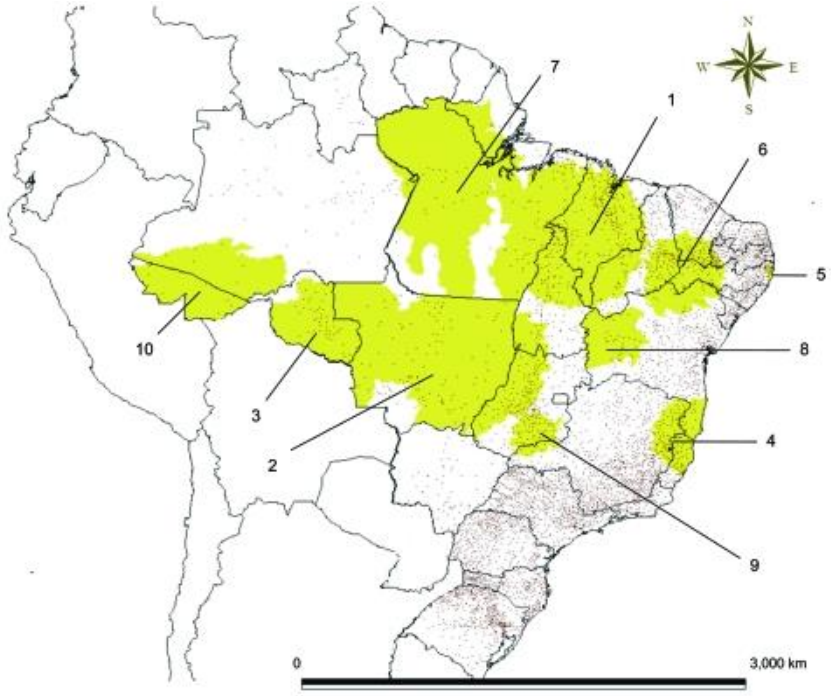


Figure 1.2: Spatial aggregation of leprosy cases in 10 major clusters in Brazil (2005-2007) (Penna, Wand-Del-Rey-de-Oliveira, & Penna, 2009)

Twenty-nine statistically significant spatial clusters were identified covering 789 municipalities with a total of 51,904 cases. Highly endemic areas showed a detection rate of 7.6 per 10,000 inhabitants showing leprosy concentration in a small proportion of the Brazilian population (Penna & Penna, 2009) .

The identification of areas of greatest vulnerability as well as previously unrecognized and significant areas of disease clustering provides an orientation for the National Hansen's Disease Control Program where transmission is expected to be a significant factor for effective epidemiological surveillance and control (Brasil MoH, 2008). Clusters (Figure 1.3) identified 53.5% of new cases detected during the period representing 17.5% of the population in 1,173 municipalities (Brasil MoH, 2008).

In the spatial analysis aggregation (clusters) of new cases detected during the period 2005-2007, part of states Maranhão, Pará, Tocantins (North) and Piauí (Northeast), in Cluster 1, also comprise the second area of greatest risk of transmission of active leprosy.

	No. cases			
Cluster order	**Observed**	**Expected**	**RR**	**LLR**
1	24,564	6,345.04	4.59	16,545.44
2	9,735	2,224.77	4.67	7,099.49
3	4,136	928.37	4.58	3,014.57
4	6,944	2,912.92	2.47	2,070.23
5	5,778	2,424.91	2.45	1,711.11
6	5,891	2,674.40	2.26	1,479.21
7	2,223	1,039.11	2.16	512.49
8	1,325	476.37	2.80	509.78
9	3,288	1,799.11	1.85	502.97
10	1,473	581.84	2.55	480.32

Figure 1.3: Ten most probable cluster of leprosy defined by using spatial scan statistics, Brazil, 2005-2007 (Penna, Wand-Del-Rey-de-Oliveira, & Penna, 2009)

1.2 Social Determinants of Health, Migration and NTDs

Neglected Tropical Diseases (NTDs) are centered on social disparities that place the most marginal at heightened risk for disease (Aagaard-Hansen & Chaignat, 2010). Social disparities are the fundamental determinants that cause migration, while additionally placing migrants at risk for disease and increasing distribution of disease. This occurs when non-immune migrants are exposed through social and environmental situations, and also when disease is introduced into previously non-endemic areas through migration (Aagaard-Hansen, Nombela, & Alvar, 2010).

1.2.1 Social Determinants of Health and NTDs

Social Determinants of Health (SDH) include those inequities found to be associated with poor health outcomes. The World Health Organization (WHO) Commission on Social Determinants of Health was commissioned to determine structural and life conditions that influence health inequities, namely unequal distribution of power, income, goods and services, as well as access to healthcare, education, and the condition of environment at home and work, and provide recommendations to address these inequalities (WHO, 2008). Further work by WHO laid out a framework to describe intermediary and structural social determinants that influence NTDs (Buruli ulcer, chagas disease, cholera, dengue fever, dracunculiasis, lymphatic filariasis, human African trypanosomiasis, leishmaniasis, leprosy, onchocerciasis, schistosomiasis, soil transmitted helminths and trachoma)

and their health inequities through an extensive review of literature (Aagaard-Hansen & Chaignat, 2010). The basic framework identified inequities in: 1) sanitation and water, 2) housing and clustering, 3) environment, 4) migration, disasters and conflict, 5) sociocultural factors and gender, and 6) poverty as factors influencing health outcomes for NTDs (Aagaard-Hansen & Chaignat, 2010).

1.2.2 Migration and NTDs

Many of the same inequities associated with NTDs are also associated with migration. Poverty not only influences population movement, but is often a condition among migrants, particularly uneducated laborers migrating for employment (Hossain, 2001; Ackah & Medvedev, 2010; IOM, 2005). Migrant living conditions, often on the outskirts of large urban areas, are plagued by poor sanitation and overcrowded conditions (Ximenes, Southgate, Smith, & Neto, 2000; Fleischer, 2007), factors that contribute to poor health. Control and elimination efforts for NTDs may be impeded by increased transmission and distribution due to migration and these poor living conditions, and has been associated with leishmaniasis (Aagaard-Hansen, Nombela, & Alvar, 2010; Costa, Pereira, & Araujo, 1990), schistosomiasis (Watts, 2008; Ximenes,et al., 2000; Kloos, Correa-Oliveira, dos Reis, Rodriques, Monteiro, & Gazzinelli, 2010) Chagas disease (Drumond & Marcopito, 2006), malaria (Duarte, Pang, & Abrahamow, 2004; Esse, et al., 2008) and leprosy (Cury et al., 2012; Kerr-Pontes , Montenegro, Barreto, Werneck, & Feldmeier, 2004; Ferreira, Ignotti, & Gamba, 2011; Montenegro, Werneck, Kerr-Pontes, & Feldmeier, 2004; Silva, Ignotti, Souza-Santos, & Hacon, 2010).

Both individual (demographic and behavioral) factors, as well as regional social environmental factors (macroeconomic conditions, employment and education availability) impact migrant health (UNPF, GSO, 2006). Rural poverty and limited employment availability influence the necessity to migrate, while urban jobs, with minimally more regular earning capacity, act as a draw to reduce or mitigate poverty and increase household stability (Ackah & Medvedev, 2010; Hossain, 2001; Rayp & Ruyssen, 2010). Although in Brazil, most migration currently is between urban areas, a long history of rural to urban migration and social networks between migration origin and destination communities facilitated through this movement, have established migration flow throughout the country (Golgher, Rosa, & Araujo Jr, 2008). These social networks often influence population flow and act cumulatively to increase movement between established origin and destination areas over time (Garip, 2008; Massey, 1990). Circular migration, is less likely to be measured (Skeldon, 2003) and contributes to the majority of population movement which takes place inside countries (UNDP, 2009). Circular movement and temporary living conditions are a relevant factor in poor urban environments that often mimic lifestyles in rural areas (Beguy, Bocquier, & Zulu, 2010).

1.2.3 Migration in Brazil

Migration has historically been part of the history of Brazil over the last century. Large numbers of migrants are from the north and northeastern regions of Brazil, where out-migration has centered. Internal migration data is supported by 2007 reports from the Pan American Health Organization (PAHO) citing the greatest migratory flow from the Northeastern region, with 17.7% of the population migrating to other regions, primarily the Southeast as the principal destination (PAHO, 2007).

According to data collected from the Brazilian Census, internal migration increased approximately 20% in the two decades prior to 2001 (IBGE, 2000). Social determinants of migration have centered on a low and illiterate population (34%) primarily from low Human Development Index (HDI) areas in the rural north and northeast of the country. Labor demand has fueled movement of an inexpensive unskilled workforce, while drought and deforestation are among the environmental conditions influencing migration (Golgher, Rosa, & Araujo Jr, 2005).

Frontier developments in areas south and east of the Amazon region, large industrial petrochemical and hydro-nuclear projects, and agriculture have facilitated movement into low urbanized areas (Golgher, et al., 2005). Migration into urban areas has mainly centered around large metropolitan centers of São Paolo and Rio de Janeiro, facilitated largely through strong social networks developed over preceding decades. Kerr-Pontes et al. (2006) cite an association with leprosy transmission when rural leprosy endemic areas affected by drought in the Northeast plains have driven rural to urban migration.

1.3 Goals and Objectives

The primary goal of this PhD thesis was to determine factors associated with leprosy and population movement through the analysis of patterns of migration, social determinants and behavioral factors that influence migration and leprosy transmission in the Northeast of Brazil. This research was conducted in coordination with MAPATOPI, a comprehensive epidemiological research program that was instituted to contribute empirical evidence to support broad-based changes in the Brazilian National leprosy program. MAPATOPI concentrates its efforts in highly endemic *Cluster 1,* maintaining the second highest leprosy endemic area in Brazil. *Cluster 1* includes the states of Maranhão, Tocantins, Piauí and Pará, located in the North and Northeast regions. The research

provided support to the Brazilian leprosy control program for improving targeted services directed towards migrating populations.

The following objectives provided the framework for reaching the goals of this project:

- Identify motives and determinants for residence change after leprosy diagnosis in 79 endemic municipalities in Tocantins state;
- Describe factors influencing migration among leprosy infected individuals in 79 endemic municipalities in Tocantins state;
- Identify social, environmental and behavioral factors associated with migration in individuals diagnosed with leprosy and in a reference population without leprosy in four endemic municipalities in Maranhão state;
- Determine patterns of migration and demographics associated with leprosy infection among past five year migrants in five endemic municipalities in Maranhão state.

1.4 Study Sites

The study sites were located in the Northeast of Brazil among municipalities in the states of Maranhão and Tocantins identified as endemic areas in Cluster 1. In Maranhão, research was conducted in five municipalities, and in Tocantins, data was collected in 79 municipalities.

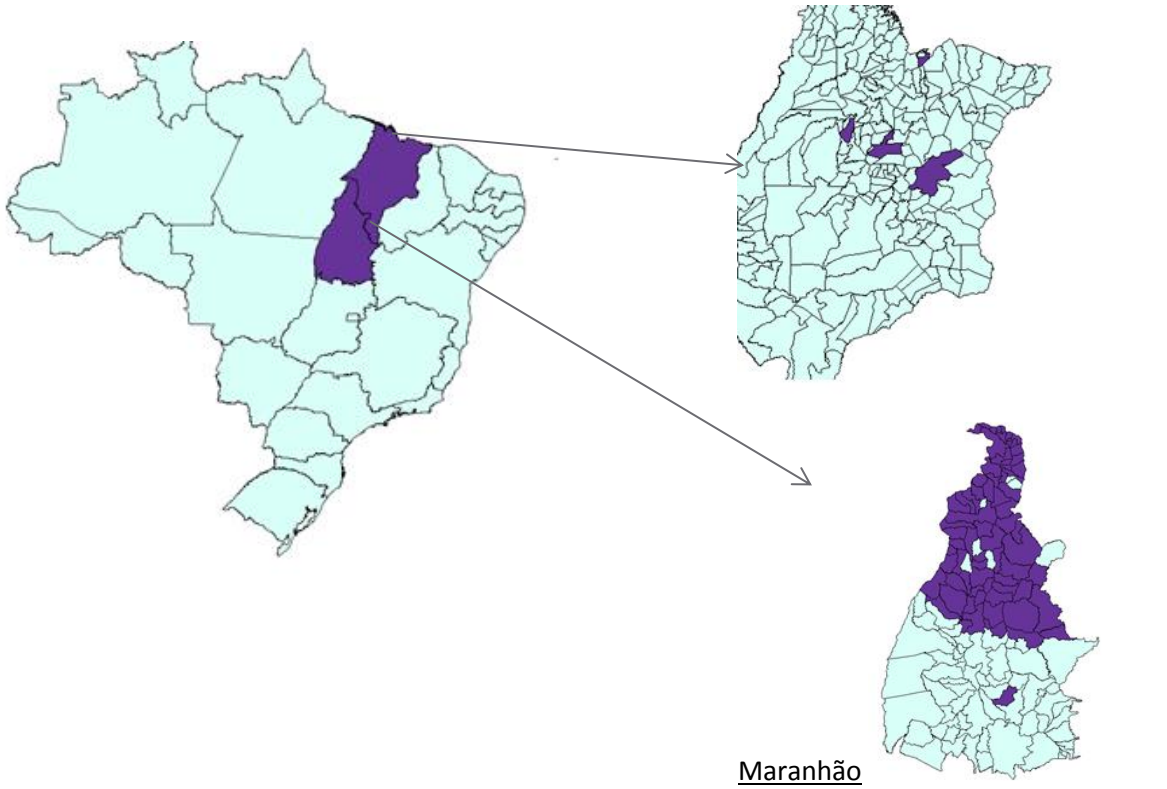


Figure 1.4: Study sites: Endemic clusters in the states of Tocantins and Maranhão

1.5 References

Aagaard-Hansen, J., & Chaignat, C. (2010). Neglected tropical diseases: equity and social determinants. In E. Blas & A. S. Kurup (Eds.), *Equity, social determinants and public health programmes.* Geneva: World Health Organization (WHO).

Aagaard-Hansen, .J, Nombela, N., & Alvar, J. (2010). Population movement: a key factor in the epidemiology of neglected tropical diseases. *Trop Med Int Health*, *15*(11), 1281-1288.

Ackah, C., & Medvedev, D. (2010). *Internal migration in Ghana: Determinants and welfare impacts.* Washington, D.C.: World Bank/West Africa Poverty Reduction and Economic Management Unit (World Bank Policy Research Working Paper Series, 5273).

Argawl, A.T., Shannon, E.J., Assefa, A., Mikru, F.S., Mariam, B.K., & Malone, J.B. (2006). A geospatial risk assessment model for leprosy in Ethiopia based on environmental thermal-hydrological regime analysis. *Geospatial Health, 1*, 105-113.

Beguy, D., Bocquier, P., & Zulu, E. (2010). Circular migration patterns and determinants in Nairobi slum settlements. *Demogr Res, 23*, 549-86.

Brazil MoH. (2008). *Situação epidemiológica da hanseníase no Brasil.* Secretaria de Vigilância em Saúde; Programa Nacional de Controle da Hanseníase, 2008.

Brazil MoH. (2011). *Coeficiente de detecção geral de casos novos de hanseníase .* Retrieved from http://portal.saude.gov.br/portal/arquivos/pdf/graf_5_coeficiente_deteccao_geral_casos1990_2010.pdf.

Brazil MoH. (2012). *Número e percentual, Casos novos de hanseníase: número, coeficiente e percentual, faixa etária, classificação operacional, sexo, grau de incapacidade, contatos examinados, por estados e regiões, Brasil, 2011.* Retrieved from http://portal.saude.gov.br/portal/arquivos/pdf/indi_operacionais_epimieologicos_hans_br_2011.pdf.

Chaturvedi, S.K., Singh, G., & Gupta, N. (2005). Stigma experience in skin disorders: an Indian perspective. *Dermatol Clin, 23*(4), 635-642.

Costa, C., Pereira, H., & Araujo, M. (1990). Visceral leishmaniasis epidemic in Piaui state, Brazil 1980-1986. *Rev Saude Publ, 24*(5), 361-72.

Cury, M., Paschoal, V., Nardi, S., Chierotti, A., Rodrigues, A.L., & Chiaravalloti-Neto, F. (2012). Spatial analysis of leprosy incidence and associated socioeconomic factors. *Rev Saude Publ, 46*(1), 110-118.

Desikan, K., & Sreevatsa. (1995). Extended studies on the viability of M. leprae outside the human body. *Lepr Rev, 66*, 287-295.

Drumond, J., & Marcopito, L. (2006). Internal migration and distribution of chagas disease mortality, Brazil 1981-1998. *Cad Saude Publica, 22*, 2131-40.

Duarte, E.G., Pang, L., & Abrahamow, M. (2004). Epidemiology of malaria in a hypoendemic Brazilian Amazon migrant population: A cohort study. *Am J Trop Med Hyg, 70*(3), 229-237.

Durães S., Guedes, L., Cunha, M., Magnanini, M., & Oliveira, M. (2010). Epidemiologic study of 107 cases of families with leprosy in Duque deCaxias, Rio de Janeiro, Brazil. *An Bras Dermatol, 85*(3), 339-45.

Esse, C., Utzinger, J., Tschannen, A., Raso, G., Pfeiffer, C., Granado, S., Koudou, B.G., N'Goran, E.K., Cisse, G., Giradin, O., Tanner, M., & Obrist, B. (2008). Social and cultural aspects of malaria and its control in central Cote d'Ivoire. *Malaria J*, 224.

Ferreira, S., Ignotti, E., & Gamba, M. (2011). Factors associated to relapse of leprosy in Mato Grosso, Central-Western Brazil. *Rev Saude Publ, 45*(4), 756-64.

Fine, P., Sterne, J., Ponninghaus, J., Bliss, L., Saul, J., Chihuana, A., Munthali, M. & Warndorff, D.K. (1997). Household and dwelling contact as risk factors for leprosy in Northern Malawi. *Am J Epidemiol, 146*(1), 91-102.

Fischer, E., De Vlas, S., Meima, A., Habbema, D., & Richardus, J. (2010). Different Mechanisms for Heterogeneity in Leprosy Susceptibility Can Explain Disease Clustering within Households . *PLoS One, 5*(11), e14061.

Fleischer, A. (2007). Family, obligations, and migration: The role of kinship in Cameroon. *Demogr Res, 16*, 414-40.

Garip, F. (2008). Social Capital and Migration: How Do Similar Resources Lead to Divergent Outcomes? *Demography, 45*(3), 591-617.

Golgher A, Rosa CH, Araujo Jr AF. The determinants of migration in Brazil In: Proceedings of the 33rd Brazilian Economics Meeting; Niteroi, RJ: ANPEC; 2005. p. 1-20.

Golgher, A., Rosa, C., & Araujo Jr, A. (2008). Determinants of migration in Brazil: Regional Polarization and Povety Traps. *Papeles Poblac,* (56), 135-171.

Hossain, M.Z. (2001). *Rural-urban migration in Bangladesh: a micro-level study*. Paper presented at XXIV International Union for the Scientific Study of Population (IUSSP) General Population Conference; Aug 20-24. Salvador, BA Brazil; 2001. http://www.archive-iussp.org/Brazil2001/s20/S28_P02_Hossain.pdf.

Hotez, P., Bottazi, M., Franco-Paredes, C., Ault, S., & Periago, M. (2008). The Neglected Tropical Diseases of Latin America and the Caribbean: A review of disease burden and distribution and a roadmap for control and elimination. Retrieved from http://www.plosntds.org/article/info%3Adoi%2F10.1371%2Fjournal.pntd.0000300. *PLoS Neglec Trop D, 12*(5).

Instituto Brasileiro de Geografia e Estatística (IBGE). (2000). *Census 2000.* Brasil Instituto Brasileiro de Geografia e Estatística .

International Organization for Migration (IOM). (2005). *Internal Migration and Development: A Global Perspective.* eds. Deshingkar P, Grimm S.

Kerr-Pontes, L.R.S., Barreto, M.L., Evangelista, C..M.N., Rodrigues, L.C., Heukelbach, J., & Feldmeier, H. (2006). Socioeconomic, environmental and behavioral risk factors for leprosy in North-east Brazil: results of a case-control study. *Int J Epidemiol, 35*(4), 994-1000.

Kerr-Pontes, L.R.S., Montenegro, A.C., Barreto, M.L., Werneck, G.L., & Feldmeier, H. (2004). Inequality and leprosy in Northeast Brazil: an ecological study. *Int J Epidemiol, 33*, 262-69.

Kloos, H., Correa-Oliveira, R., dos Reis, D.C., Rodriques, E., Monteiro, L.A.S., & Gazzinelli, A. (2010). The role of population movement in the epidemiology and control of schistosomiasis in Brazil: a preliminary typology of population movement. *Mem Inst Oswaldo Cruz, 105*(4), 578-86.

Kumar, A., Yadav, V.S., Girdhar, A., & Girdhar, B.K. (2005). Leprosy situation in the slums of Agra City: epidemiological findings. *Ind JLepr, 77*(3), 239-245.

Lavania, M., Katoch, K., Katoch, V., Gupta, A., Chauhan, D., Sharma, R., Gandhi, R., Chauhan, V., Bansal, G., Sachan, P., Yadav, V.S., & Jadhav, R. (2008). Detection of viable Mycobacterium leprae in soil samples: insights into possible sources of transmission of leprosy. *Infect Genet Evol, 8*(5), 627-31.

Lockwood. D., & Suneetha, S. (2005). Leprosy: too complex a disease for a simple elimination paradigm. *B World Health Organ, 83*(3), 230-235.

Martinez, T.S., Figueira, M.M., Costa, A.V., Gonçalves, M.A., Goulart, L.R., & Goulart, I.M. (2011). Oral mucosa as a source of Mycobacterium leprae infection and transmission, and implications of bacterial DNA detection and the immunological status. *Clin Microbiol Infect., 17(11):1653-8*.

Massey, D. (1990). Social Structure, Household Strategies, and the Cumulative Causation of Migration. *Popul Index, 56*, 3-26.

Mathers, C,. Ezzati, M., & Lopez, A. (2007). Measuring the burden of neglected tropical diseases: the global burden of disease framework. *PLoS Negectl Trop D, 1*(2), 114.

Matsuoka, M., Isumi, S.B.T., Nakata, N., & Saeki, K. (1999). *Mycobacterium leprae* DNA in daily using water as a possible source of leprosy infection. *Indian J Lepr. , 71*(1), 61-7.

Moet, F., Pahan, D., Schuring, R., Oskam, L., & Richardus, J. (2006). Physical distance, genetic relationship, age and leprosy classification are independent risk factors for leprosy in contacts of patients with leprosy. *J Infect Dis, 193*, 346-53.

Montenegro, A., Werneck, G.L., Kerr-Pontes, L.R.S., & Feldmeier, H. (2004). Spatial analysis of the distribution of leprosy in the state of Ceara, Northeast Brazil. *Mem I Oswaldo Cruz, 99*(7), 683-86.

Oliveira, M., Mendes, C., Tardin, R., Cunha, M., & Arruda, A. (2003). Social representation of Hansen's disease thirty years after the term "leprosy" was replaced in Brazil. *História, Ciências, Saúde – Manguinhos, 10*(Suppl 1), 41-48.

PAHO. (2007). *Technical Cooperation Strategy for PAHO/WHO and the Federative Republic of Brazil, 2008-2012.* Retrieved from http://www.PAHO.org.

Pedley, J. (1970). Composite skin contact smears: a method of demonstrating the nonemergence of Mycobacterium leprae from intact lepromatous skin. *Lepr Rev, 41*, 31.

Pedley, J. (1973). The nasal mucus in leprosy. *Lepr Rev, 44*, 33.

Penna, M.L.F., & Penna, G. (2009). The epidemiological behavior of leprosy in Brazil. Lepr Rev, *80*, 332-44.

Penna, M.L.F., Oliveira, M.L.W., & Penna, G. (2009). Spatial distribution of leprosy in the Amazon region of Brazil. Retrieved from http://wwwnc.cdc.gov/eid/article/15/4/08-1378.htm. *Emerg Infect Dis*. 15(4), 650-652.

Rayp, G., Ruyssen, I. (2010) *Africa on the move: an extended gravity model of intra-regional migration.* Paper presented at Migration, A World in Motion: A multinational Conference on Migration and Migration Policy, Association for Public Policy Analysis and Management (APPAM); February 18-20. Maastricht, Netherlands; 2010 . Retrieved from http://umdcipe.org/conferences/Maastricht/conf_papers/Papers/Africa_on_the_Move.pdf .

Rees, R., & McDougall, A. (1977). Airborne infection with Mycobacterium leprae in mice. *J Med Microbiol, 10*(1), 63-8.

Sales, A., Leon, A., Duppre, N., Hacker, M., Nery, J., Sarno, E., & Penna, M.L.F. (2011). Leprosy among patient contacts: A multilevel study of risk factors. *PLoS Neglect Trop D 5*(3), e1013.

Silva, D.R.X., Ignotti, E., Souza-Santos, R., & Hacon, S.S. (2010). Hanseníase, condições sociais e desmatamento na Amazonia brasileira. *Rev Panam Salud Publica, 27*(4), 268-75.

Skeldon ,R. (2003). Migration and Poverty. *African Migration and Urbanization in Comparative Perspective.* Johannesburg, South Africa, June 4-7.

Tsutsumi, A., Izutsu, T., Islam, A.M., Maksuda, A.N., Kato, H., & Wakai, S. (2007). The quality of life, mental health, and perceived stigma of leprosy patients in Bangladesh. *Soc Sci Med, 64*(12), 2443-2453.

UNDP. (2009). *Overcoming barriers: Human mobility and development.* UNDP. New York: UNDP.

UNPF, GSO. (2006). *The 2004 Vietnam Migration Survey: Migration and Health.* Hanoi.

van Beers, S., Hatta, M., & Klatser, P. (1999). Patient contact is the major determinant in incident leprosy: implications for future control. *Int J Lepr Other Mycobact Dis, 67*(2), 119-28.

Watts, S. (2008). *The Social Determinants of Schistosomiasis.* Retrieved from TropIKA.net: http://www.tropika.net/review/051114-Schistosomiasis_Social_Determinants/article.pdf

WHO. (2008). *Closing the gap in a generation: health equity through action on the social determinants of health. Final Report.* Commission on Social Determinants of Health (CSDH). Geneva: World Health Organization.

WHO. (2009). *Enhanced Global Strategy for Further Reducing the Disease Burden due to Leprosy (2011-2015).* New Delhi, India: World Health Organization.

WHO. (2010). *Weekly epidemiological record, (85)35,* World Health Organization, 337-348.

WHO. (2011). *Weekly Epidemiological Record, (86)36*, World Health Organization, 389-400.

WHO. (1991). *World Health Assembly (WHA) resolution to elimnate leprosy.* Retrieved from http://www.who.int/lep/strategy/wha/en/index.html

Ximenes, R., Southgate, B., Smith, P., & Neto, L. (2000). Migration and urban schistosomiasis, the case of Sao Lourenco da Mata, Northeast of Brazil. *Rev Inst Med Trop S. Paulo, 42*(4), 209-17.

2 Motives and determinants for residence change after leprosy diagnosis, central Brazil†

Christine Murto*,** Liana Ariza*, Alexcian Rodrigues Oliveira*, Olga André Chichava*, Carlos Henrique Alencar*, Luciana Ferreira Marques da Silva***, Marcel Tanner**, Jorg Heukelbach*, ****

* *Department of Community Health, School of Medicine, Federal University of Ceará, Fortaleza, Brazil*
** *Swiss Tropical and Public Health Institute, University of Basel, Basel, Switzerland*
*** *State Leprosy Control Program; State Health Secretariat of Tocantins, Palmas, Brazil*
**** *Anton Breinl Centre for Public Health and Tropical Medicine; School of Public Health, Tropical Medicine and Rehabilitation Sciences, James Cook University, Townsville, Australia*

Correspondence to: Jorg Heukelbach, Departamento de Saúde Comunitária, Faculdade de Medicina, Universidade Federal do Ceará, Rua Professor Costa Mendes 1608, 5. andar, Fortaleza CE, 60430-140, Brazil. (Tel: ++55-85-33668045; Fax: ++55-85-33668050; E-mail: heukelbach@web.de)

† This publication is part of the MAPATOPI study (an interdisciplinary project providing evidence for improving the Brazilian leprosy control program), co-financed by the Brazilian Research Council (CNPq) and the Department of Science and Technology of the Brazilian Ministry of Health (DECIT).

This article has been published in

Leprosy Review 2011, 83(1): 16-23

2.1 Abstract

Objective: To determine the extent of population movement after diagnosis with leprosy and to describe the underlying motives and determinants for relocation.

Design: A cross-sectional study was conducted among those newly diagnosed with leprosy in 79 endemic municipalities in the state of Tocantins, central Brazil. Individuals were identified through the National Information System for Notifiable Diseases (SINAN) database and interviewed with structured questionnaires.

Results: In total, 224 (20.9%) out of 1070 individuals relocated after their diagnosis with leprosy. Respondents moved to another neighbourhood in the same municipality (*n*=178, 79.5%), followed by another municipality in Tocantins state (*n*=26, 11.2%) and in another state (*n*=11, 4.9%). The primary motives and/or determinants for relocation were: home ownership (*n*=47, 20.9%), familial reasons (*n*=43, 19.2%), to seek better living conditions (*n*=35, 15.6%), employment (*n*=26, 11.6%), and better neighbourhood (*n*=22, 9.8%). Other motives were related to better access to leprosy diagnosis/treatment (*n*=11, 4.9%), owner-terminated rental (*n*=5, 2.2%), personal finances/could not afford housing (*n*=4, 1.8%). Perceived stigma due to leprosy was mentioned by one participant (0.5%).

Conclusion: In Tocantins state, population movement is lower among individuals recently diagnosed with leprosy, as compared to the overall population. The primary motives for relocation after leprosy diagnosis were related to lifestyle changes. Stigma and treatment-related reasons did not appear to be common motives for population movement. These results may reflect policy changes instituted from the Brazilian Program of Leprosy Control to decentralise leprosy services and intensify health education campaigns within a broader concept of Information, Education and Communication.

2.2 Introduction

Recent research surrounding population movement and infectious diseases has centred on exposure (Clark, Collinson, Kahn, Drullinger, & Tollman, 2007; Field, et al., 2010; Moore, Lightstone, Javid, & Friedland, 2002), risk (Deane, Parkhurst, & Johnston, 2010; Drumond & Marcopito, 2006; Comm, Noorhidayah, & Osman, 1999) and transmission to and from communities of origin and destination (Bayer, et al., 2009; Soto, 2009; Stoddard, et al., 2009; Yaméogo, et al., 2005), and the combination of these factors (Aagaard-Hansen, Nombela, & Alvar, 2010; Kloos, et al., 2010). The institutional burden of imported disease, patient management and environmental control of disease in non-endemic areas, imported disease in conflict settings, restricted access to health facilities, and reduced migration due to disability have been discussed for malaria, hepatitis, chagas disease, HIV/AIDS and other serious life disrupting and/or stigmatising diseases (Ahmed & Foster, 2010; Mills, Ford, Singh, & Eyawo, 2009; Schmunis, 2007; Osorio, Todd, Pearce, & Bradley, 2007; Moorin, Holman, Garfield, & Brameld, 2006). However, there has been limited research on the motives for population movement after disease diagnosis. The extent to which the personal choice to move is influenced by the disease itself, stigma, lifestyle, macro-conditions such as access to treatment, or as a response to health policy or other socio-economic conditions is largely unexplored.

The International Federation of Anti-Leprosy Associations (ILEP) review of leprosy research (2002–2009) found that despite cultural differences across countries with a high incidence of leprosy, areas of life affected were similar (ILEP, 2010). Leprosy research in Nepal (Heijnders, 2004), Bangladesh (ILEP, 2010), India (Raju, Rao, & Mutatkar, 2008), Nigeria (Awofeso, 1996), Indonesia (Schuller, et al., 2010), and Brazil (Varkevisser, et al., 2009) highlights issues associated with social exclusion. While individuals with leprosy may be separated from family and community activities, in some cases they leave the community entirely - as migrant labourers or otherwise - until symptoms subside (Heijnders, 2004).

In the present paper, we investigated the motives and determinants for population movement after leprosy diagnosis as part of a major epidemiological study in North Brazil. The data show that stigma and health-service related factors played only a minor role in this setting where leprosy control activities are established and decentralised.

2.3 Methods

2.3.1 Study Area

Tocantins, the newest Brazilian state located in the north region, is a leprosy hyperendemic area with the highest case detection rate in Brazil (88.54/100,000 inhabitants in 2009) (Brazil MoH, 2009). With one of the fastest growing agriculture-based economies, Tocantins attracts labour migration with more than a third of the population from a different state and more than a half born in different municipalities (IBGE, 2006; IBGE, 2007; IBGE, 2008).

2.3.2 Study Design and Data Collection

This study is an integral part of an epidemiological investigation among 79 municipalities in Tocantins. All municipalities were located in an endemic cluster identified by the Brazilian Ministry of Health as high risk areas for leprosy transmission (Penna & Penna, 2009). The target population included all newly diagnosed individuals between 2006–2008 who were living in the endemic municipalities. Individuals living outside the cluster, those with mental illness or other characteristics that hindered interviews, including those under the influence of alcohol were excluded. In addition, relapsed cases and those who died after diagnosis were also not included.

Municipality Health Secretariats were informed by the Tocantins State Health Secretariat about the study and field visits were coordinated for data collection. The target population was identified through the database of the National Information System for Notifiable Diseases (*Sistema de Informação de Agravos de Notificação* – SINAN). Patients were invited through Community Health Agents to participate in the study. The study was conducted between August and December 2009. Clinical data (degree of disability) were collected from patients' charts and the disease notification forms. Demographic data (such as gender, age, place of birth) and questions for migration before and after diagnosis were investigated by interview using a structured-questionnaire. The individuals who changed residence after diagnosis were asked whether they moved to another neighbourhood, municipality and/or state and their reasons and motivations for that. To reduce interview bias, questionnaires were applied by two previously trained field investigators (OAC, ARO).

2.3.3 Data Analysis

Data were entered twice, using Epi Info software version 3.5.1 (Centers for Disease Control and Prevention, Atlanta, USA) and cross-checked for entry-related errors. Answers of open-ended questions to motivations for moving after diagnosis were grouped into categories according to

similarities. Frequency distributions were examined only for those who changed residence after diagnosis with leprosy. Data analysis was done using STATA version 9 (Stata Corporation, College Station, USA).

2.3.4 Ethics

The study was approved by the Ethical Review Board of the Federal University of Ceará (Fortaleza, Brazil) and by the Ethical Review Board of the Lutheran University of Palmas (Palmas, Brazil). Permission to perform the study was also obtained by the Tocantins State Health Secretariat, the State Leprosy Control Program and the municipalities involved.

Informed written consent was obtained from all study participants after explaining the objectives of the study. In the case of minors, consent was obtained from those responsible for them. Interviews were in private, and the diagnosis of leprosy was not given to family members or other community members.

2.4 Results

In total, 1074 interviews were conducted; 555 (51.7%) individuals were male and 519 (48.3%) female; the ages ranged from 5 to 98 years (mean=41.8; standard deviation: 19.01). Disability status at the moment of diagnosis was available in 751 cases. Of these, 75% (*n*=566) were diagnosed with Grade 0 disability, 20.6% (*n*=155) with Grade 1, and only 4.0% (*n*=30) with visible impairments (Grade 2). Eight hundred (76.2%) individuals were born in another municipality, and 179 (16.7%) had lived in another municipality or state 5 years prior to their leprosy diagnosis.

In total, 224 (20.9%) of 1070 participants with available information relocated after their diagnosis with leprosy. Of these, more than half (*n*=121, 54%) were males; the ages ranged from 5 to 83 years (mean=36.1; standard deviation: 16.1). The majority of the migrants after diagnosis (*n*=215; 96%) had lived at their current residence for 5 years or less. Of the 30 patients diagnosed with visible impairments, seven (23.3%) migrated after diagnosis, as compared to 134 (18.6%) of those diagnosed with Grade 0 or 1 (*P*=0.48).

After diagnosis, the majority of the migrant cases moved to another neighbourhood in the same municipality (*n*=178, 79.5%), followed by other municipality in Tocantins (*n*=26, 11.6%), and other state (*n*=11; 4.9%); eight respondents (3.6%) did not specify a location.

Among 194 (86.6%) of the migrant cases, information was given regarding motives. Motives for relocation after leprosy diagnosis are detailed in Table 1.

Table 2.1: Motives/determinants for moving after leprosy diagnosis (n=194).

Motive/determinant	N	%
Home ownership	47	24.2
Familial reason	43	22.2
Better living conditions	35	18.0
Employment	26	13.4
Better neighbourhood	22	11.3
Leprosy diagnosis/better access to treatment	11	5.7
Owner terminated rental/asked for house	5	2.6
Personal finances/could not afford housing	4	2.1
Leprosy discrimination/stigmatization	1	0.5

The primary motives for changing residence were related to lifestyle changes (home ownership, better living conditions, better neighbourhood), making up 53.5% of all responses. Conversely, some individuals lost housing through other circumstances including not being able to afford housing or because the home owner requested the house or terminated the rental agreement. Employment related relocation included moving 'for work' or 'for better work' in the destination, or due to unemployment or limited employment opportunities in the residence of origin. Familial reasons for moving (22.2%) was the second most common motive given and included, change in civil status due to separation (*n*=8), marriage (*n*=6), caring for family members (*n*=6), moving due to spouse's employment (*n*=3), besides other reasons (*n*=20).

Few cited moving because of their leprosy diagnosis and/or for the purpose of accessing health services. Two individuals moved to access treatment and three for better treatment. Only one individual pointed to discrimination and feeling stigmatised as a reason for moving after leprosy diagnosis.

2.5 Discussion

This study shows that patients recently diagnosed with leprosy changed residence primarily as a result of lifestyle changes and to a much lesser extent for better access to treatment or as a result of stigma and discrimination. In fact, the Brazilian Ministry of Health, through the Office of Leprosy Control, has placed a strong emphasis on reducing incidence by integrating leprosy services into the municipal level public health system (decentralisation) and minimising stigma through public health

campaigns (Souza, el-Azhary, & Foss, 2009). Decentralisation allows for community health centres to be the patient point of contact for both diagnosis and treatment, provided free of charge. Our findings suggest that these policies have resulted in a reduced burden of disease management and relocation for treatment so that patients can divert their attention to positive lifestyle changes. The remarkable age range of newly diagnosed cases from 5 to 98 years indicates ongoing transmission, but also the positive impact of control efforts and early diagnosis.

According to the Brazilian National Household Study (*PNAD*), approximately 40% of the residents in Tocantins were born in a municipality other than where they were residents between 2006 to 2008. Another 10% were born in the municipality where they were residing, but have also lived elsewhere (IBGE, 2006; IBGE, 2007; IBGE, 2008). Thus, the results from the study indicate that although many were born in another state or municipality and one-third migrated prior to diagnosis, population movement is significantly lower among individuals recently diagnosed with leprosy, as compared to the overall population in Tocantins. This finding may have positive implications for treatment adherence if translated effectively into public health practice, particularly the Information, Education and Communication (IEC) approaches. An earlier publication in the same study area found that residence change was associated with lower treatment adherence because patients would lose contact with community health workers and other health professionals in municipal clinics (Chichava, et al., 2011). As such, the current decentralised service provision for both diagnosis and treatment, offered through the network of community health centres, enhances leprosy control in Tocantins and improves new cases detection. This potentially reduces incidence through retention and treatment of new cases in health care facilities, over the long run. There is a clear indication that the current leprosy diagnostic capacity is related to access to health centres (Penna, Oliveira, Carmo, Penna, & Temporao, 2008).

The data further indicate that the majority of individuals moved within the same neighborhood. The primary motivation was to purchase a home, which was strongest among those who stayed in the same neighbourhood. For those who remained in Tocantins, but moved to a different municipality, the purchase of a home was less often a motive and determining factor. In this context, it is important to remember that Brazil has a strong history of home ownership, with 74% of the population living in privately owned homes (IBGE, 2000). Home ownership in Tocantins is comparable to the national average (71%), however home ownership among low income residents in Tocantins (those living on one minimum salary or less) is higher than the national estimates (IBGE, 2006; IBGE, 2007; IBGE, 2008). The prevalent low-income status among more than half of the respondents could account for the importance of home ownership as a motive for residence change.

An important finding of this study is that leprosy diagnosis does not seem to present a significant financial barrier in this regard.

In terms of living conditions, sanitation in Tocantins is less well-off than the country overall. Both rudimentary (57%) or no waste disposal (13%) are significantly higher in Tocantins compared nationally at 21% and 4% respectively (IBGE, PNAD, 2009). Poor household structure could precipitate movement for health reasons or otherwise. Future research should identify whether better sanitation services and improved environment are important determinants for mobility among those diagnosed with infectious diseases.

Familial reasons were also a strong motive for moving, primarily for marriage or separation, caring for family members and to a lesser extent for spousal employment. Study estimates for relocation due to change in civil status is difficult to compare to governmental estimates as this process is often informal and outside of the judicial system. In Tocantins, 84% of cohabitation arrangements are unmarried spousal relationships (IBGE, 2009). Interestingly, the small number of residence changes due to divorce or separation in the context of the overall sample did not appear to be a significant reflection of stigma from intimate partners due to leprosy diagnosis. Additionally, this concept is strengthened by change in residence due to marriage after recent diagnosis.

Internal migration for employment has traditionally been a significant factor in migrant flow in Brazil (Golgher, Rosa, & Araujo Jr, 2005). Despite new leprosy diagnosis, employment remained an important motive for migration among respondents in the study. Socioeconomic changes in Brazil over the last 10 years include a stabilised Brazilian economy, increased household income, and improved job market also in the North and Northeast of the country (IBGE, 2008) where the majority of clusters of highly endemic areas for leprosy transmission have been identified (Penna & Penna, 2009). These influences have changed the landscape of migration in Brazil, historically from the North and Northeast to Southeast metropolitan centres (Golgher, et al., 2005). A decrease in long-distance migration, particularly among the low income population with a preference for the North and Northeast urban centres, has made population movement less costly but perhaps more accessible (Golgher, et al., 2005). Growth in construction nationally (IBGE, 2008) and the agricultural sector has played a significant role in attracting labour, with agriculture employment reversing migration to rural-rural and urban rural flow (Golgher,et al., 2005). Shorter distance migration often allows labour migrants to maintain relationships with their home municipality health centres where relationships have been established.

Few respondents changed residence to seek better treatment and/or due to stigma. Stigma is common in countries most affected by leprosy (ILEP, 2010), sometimes prompting complete temporary or permanent withdrawal from the community. Both self-imposed withdrawal and complete banishment from family and social networks as has been noted in research in India (Barrett, 2005) and Nepal (Heijnders, 2004). Recent policy change in Brazil has likely had an impact on early diagnosis and stigmatization as a result of visible physical symptoms and disability. The majority of respondents presenting with Grade 0 disability at diagnosis demonstrates early diagnosis in most cases. Additionally, the adoption of the term 'Hansen's disease' instead of 'leprosy' by the Ministry of Health, and IEC campaigns consistently implemented throughout Brazil, may have been a contributing factor to reducing stigma and thus population movement as a consequence of discrimination (Oliveira, Mendes, Tardin, Cunha, & Arruda, 2003). While it could be argued that subconscious motivations or implicit actions in changing residence for employment or family may be a protective factor for the individual and as a response to culturally constructed social stigma, the majority of respondents' focus on movement as an effort to make positive improvements their life conditions appears to be consistent with the overall population in Brazil.

Our study is subject to some limitations. We only included those respondents living inside the endemic cluster where the study was conducted and did not analyze data from other municipalities such as the state capital. Those respondents who moved to a municipality outside the cluster after diagnosis could therefore not be included in the sample.

In conclusion, Brazilian policy changes offering decentralised leprosy control and treatment campaigns accompanied by IEC efforts aimed at reducing stigma, appears to have affected the reduction in residence change/mobility among those newly diagnosed with leprosy in central Brazil. Improved socioeconomic conditions in the country facilitating employment, opportunities to improve the quality of life, and strong socio-cultural influences in Brazil, such as home ownership and strong familial bonds in individuals with leprosy appear to be comparable to the population in general. Serious illness is often a turning point in the life course of an individual leading to overall life changes that include the taking of personal responsibility for both the physical and emotional self and family. The extent to which positive motives for personal change are influenced by leprosy in newly diagnosed patients provides an opportunity for future research. Continued measurement of the impact of policy changes to decentralise services can surely support future interventions aimed at reducing the burden of leprosy. A focus on migration in future research could provide a fertile ground for policy assessment and development.

2.6 Acknowledgments

We thank Adriana Cavalcante Ferreira, Suen de Oliveira Santos and the entire team of the State Health Secretariat of Tocantins. Collaboration of the Municipalities' Health Secretariats and Primary Health Care Centers is acknowledged. We are also grateful to all patients that kindly agreed to participate in the study. The research project 'MAPATOPI' was financed by the *Conselho Nacional de Desenvolvimento Científico e Tecnológico* (CNPq) and the Department of Science and Technology of the Brazilian Ministry of Health (DECIT), Brazil. JH is research fellow from CNPq. OAC received a 'PEC-PG' scholarship from CNPq, ARO a Master's scholarship from *Fundação Cearense de Apoio ao Desenvolvimento Científico e Tecnológico* (FUNCAP), and CHA a PhD scholarship from *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* (CAPES), Brazil. Charles Kaplan of the Graduate College of Social Work at the University of Houston provided insightful comments on the manuscript.

2.7 References

Aagaard-Hansen J., Nombela, N., & Alvar, J. (2010). Population movement: a key factor in the epidemiology of neglected tropical diseases. *Trop Med Int Health*, 1281-1288.

Ahmed, F., & Foster, G. (2010). Global hepatitis, migration and its impact on Western healthcare. *Gut, 59*, 1009-11.

Awofeso, N. (1996). Stigma and Socio-economic reintegration of leprosy sufferers in Nigeria. *Acta Leprol, 1996; 10: 89-91., 10*, 98-91.

Barrett, R. (2005). Self Mortification and the Stigma of Leprosy in Northern Índia. *Med Anth Qtly*, 216-230.

Bayer, A.M., Hunter, G.C., Gilman, R.H., Cornejo del Carpio, J.G., Naquira, C., Bern, C., & Levy, M.Z. (2009). Chagas disease, migration and community settlement patterns in Arequipa, Peru. *PLoS Negl Trop Dis, 3*, e567.

Brazil MoH. (2009). *Hanseníase: Coeficiente de detecção geral de casos novos de hanseníase. Brasil e estados 2009.* Retrieved from http://dtr2004.saude.gov.br/sinanweb/tabnet/dh?sinannet/hanseniase/bases/Hansbrnet.def

Chichava, O.A., Ariza, L., Oliveira, A.R., Ferreira, A.C., da Silva, L.F., Barbosa, A.N., Ramos, Jr., A.N., & Heukelbach, J. (2011). Reasons for Interrupting Multidrug Therapy Against Leprosy. *Leprosy Review, 82*, 78-9.

Clark, S., Collinson, M., Kahn, K., Drullinger, K., & Tollman, S. (2007). Returning home to die: circular labour migration and mortality in South Africa. *Scand J Public Health , 69 (Suppl)*, 35-44.

Comm, S., Noorhidayah, I., & Osman, A. (1999). Seasonal migration: a case control study of malaria prevention in Sabah. *Med J Malaysia, 54*, 200-9.

Deane, K., Parkhurst, J., & Johnston, D. (2010). Linking migration, mobility and HIV. *Trop Med Int Health, 15*, 1458-63.

Drumond, J., & Marcopito, L. (2006). Internal migration and distribution of chagas disease mortality, Brazil 1981-1998. *Cad Saude Publica, 22*, 2131-40.

Field, V., Gautret, P., Schlagenhauf, P., Burchard, G., Caumes, E., Jensenius, M., Castelli, F., Gkrania-Klotsas, E., Weld, L., Lopez-Velez, R., de Vries, P., von Sonnenburg, F., Loutan, L., Parola, P., & Euro TravNet network. (2010). Travel and migration associated infectious diseases morbidity in Europe. *BMC Infect Dis, 10*, 330.

Golgher A, Rosa CH, Araujo Jr AF. The determinants of migration in Brazil In: Proceedings of the 33rd Brazilian Economics Meeting; Niteroi, RJ: ANPEC; 2005. p. 1-20.

Heijnders, M. (2004). The dynamics of stigma in leprosy. *Int J Lepr Other Mycobact Dis, 72*, 437-47.

Instituto Brasileiro de Geografia e Estatística (IBGE). (2010). *Results of Population Census 2010*. Retrieved from ftp://ftp.ibge.gov.br/Censos/Censo_Demografico_2010/Nupcialidade_Fecundidade_Migracao/tab1_3.pdf.

Instituto Brasileiro de Geografia e Estatística (IBGE). (2006). *Pesquisa Nacional por Amostra de Domicílios (PNAD).* Retrieved from http://www.ibge.gov.br.

Instituto Brasileiro de Geografia e Estatística (IBGE). (2007). *Pesquisa Nacional por Amostra de Domicílios (PNAD).* Retrieved from http://www.ibge.gov.br.

Instituto Brasileiro de Geografia e Estatística (IBGE). (2008). *Job Market Advances, Income remains On Upward Trend and Home Internet Access Increases. Social Communication.* Retrieved from National Household Sample Survey 2008. Retrieved from http://www.IBGE.gov.br.

Instituto Brasileiro de Geografia e Estatística (IBGE). (2008). *Pesquisa Nacional por Amostra de Domicílios (PNAD).* Retrieved from http://www.ibge.gov.br.

Instituto Brasileiro de Geografia e Estatística (IBGE). (2009). *Coordenação de População e Indicadores Sociais, Estatísticas do Registro Civil 2009.* Retrieved from http://www.IBGE.gov.br.

Instituto Brasileiro de Geografia e Estatística (IBGE). (2009). *Pesquisa Nacional por Amostra de Domicílios (PNAD).* Retrieved from http://www.ibge.gov.br.

ILEP. (2010). *Review of Leprosy Research Evidence (2002-2009) and Implications for Current Policy and Practice.* London: ILEP Technical Commission.

Kloos, H., Correa-Oliveira, R., dos Reis, D., Rodriques, E., Monteiro, L., & Gazzinelli, A. (2010). The role of population movement in the epidemiology and control of schistosomiasis in Brazil: a preliminary typology of population movement. *Mem Inst Oswaldo Cruz, 105*(4), 578-86.

Mills, E., Ford, N., Singh, S., & Eyawo, O. (2009). Providing antiretroviral care in conflict settings. *Curr HIV/AIDS Rep, 6*, 201-9.

Moore, D., Lightstone, L., Javid, B., & Friedland, J. (2002). High rates of tuberculosis in end-stage renal failure: the impact of international migration. *Emerg Infect Dis, 8*, 77-8.

Moorin, R., Holman, C., Garfield, C., & Brameld, K. (2006). Health related migration: evidence of reduced "urban-drift". *Health Place, 12*, 131-40.

Oliveira, M., Mendes, C., Tardin, R., Cunha, M., & Arruda, A. (2003). Social representation of Hansen.s disease thirty years after the term leprosy was replaced in Brazil. *História Ciências Saúde, 10 (suppl 1)*, 41-48.

Osorio, L. Todd, J., Pearce, R., & Bradley, D. (2007). The role of imported cases in the epidemiology of urban Plasmodium falciparum malaria in Quibdó, Colombia. *Trop Med Int Health., 12*, 331-41.

Penna, M.L.F., & Penna, G. (2009). The epidemiological behavior of leprosy in Brazil. *80*, 332-44.

Penna, M.L.F., Oliveira, M.L.W., Carmo, E., Penna, G., & Temporao, J. (2008). The influence of increased access to basic healthcare on the trends in Hansen's disease detection rate in Brazil from 1980 to 2006. *Rev da Soc Bras Med Trop, 41*(Supp II), 6-10.

Raju, M., Rao, P., & Mutatkar, R. (2008). A study on community-based approaches to reduce leprosy stigma in India. *Indian J Lepr, 80*, 267-73.

Schmunis, G. (2007). Epidemiology of Chagas disease in non-endemic countries: the role of international migration. *Mem Inst Oswaldo Cruz, 102 (Suppl 1)*, 75-85.

Schuller, I., van Brakel, W.H., Van Der Vliet, I., Beise, K., Wardhani, L., Silwana, S., Eiteren, M., Hasibuan, Y., & Asapa, A.S. (2010). The way women experience disabilities and especially disabilities related to leprosy in rural areas in South Sulawesi, Indonesia. *Asia Pacific Disability Rehabilitation Journal, 21*, 60-70.

Soto, S. (2009). Human migration and infectious diseases. *Clin Microbiol Infect, 15 (Suppl 1)*, 26-8.

Souza, A., el-Azhary, R., & Foss, N. (2009). Management of chronic diseases: an overview of the Brazilian governmental leprosy program. *Int J Dermatol, 48*, 109-16.

Stoddard, S., Morrison, A., Vazquez-Prokopec, G., Soldan, V., Kochel, T., Kitron, U., Elder, J.P., & Scott, T.W. (2009). The role of human movement in the transmission of vector-borne pathogens. *PLOS NTDs, 3*(7), e481.

Varkevisser, C.M., Lever, P., Alubo, O., Burathoki, K., Idawani, C., Moreira, T.M., Patrobas, P., & Yulizar, M. (2009). Gender and leprosy: case studies in Indonesia, Nigeria, Nepal and Brazil. *Lepr Rev, 80*, 65-76.

Yaméogo, K.R, Perry, R.T, Yaméogo, A., Kambiré, C., Kondé, M.K., Nshimirimana, D., Kezaala, R., Hersh, B.S., Cairns, K.L., & Strebel, P. (2005). Migration as a risk factor for measles after a mass vaccination campaign, Burkina Faso. *Int J Epidemiol , 34*, 556-64.

3 Migration among individuals with leprosy: A population-based study in central Brazil†

Christine Murto (1,2), Liana Ariza (3), Carlos Henrique Alencar (3), Olga André Chichava (3,) Alexcian Rodrigues Oliveira (3), Charles kaplan (4), Luciana Ferreira Marques da Silva (5), Jorg Heukelbach (3,6)*

1. Swiss Tropical and Public Health Institute, Basel, Switzerland
2. University of Basel, Basel Switzerland
3. Department of Community Health, School of Medicine, Federal University of Ceará, Fortaleza, Brazil
4. University of Southern California, School of Social Work, Hamovitch Center for Science in the Human Services
5. State Leprosy Control Program; State Health Secretariat of Tocantins, Palmas, Brazil
6. Anton Breinl Centre for Public Health and Tropical Medicine; School of Public Health, Tropical Medicine and Rehabilitation Sciences, James Cook University, Townsville, Australia

*** Corresponding author**: Prof. Jorg Heukelbach, Departamento de Saúde Comunitária, Faculdade de Medicina, Universidade Federal do Ceará, Rua Professor Costa Mendes 1608, 5. andar, Fortaleza CE, 60430-140, Brazil. Phone: ++55-85-33668045; Fax: ++55-85-33668050. Email: heukelbach@web.de

† This publication is part of the MAPATOPI study (an interdisciplinary project providing evidence for improving the Brazilian leprosy control program), co-financed by the Brazilian Research Council (CNPq) and the Department of Science and Technology of the Brazilian Ministry of Health (DECIT).

This article was accepted for publication by

Cadernos de Saúde Pública

3.1 Abstract

This study investigates social and clinical factors associated with migration among individuals affected by leprosy. A cross-sectional study was conducted among those newly diagnosed with leprosy (2006-2008), in 79 endemic municipalities in the state of Tocantins, Brazil (n=1074). In total, 76.2% were born in a municipality different from their current residence. In the five years before diagnosis 16.7% migrated, and 3.6% migrated after leprosy diagnosis. Findings reflect aspects associated with historical rural-urban population movement in Brazil. Indicators of poverty, prominent among before-diagnosis migrants but not after-diagnosis migrants, suggest poverty as a barrier to migration, or alternatively the financial benefit of migration post-diagnosis and should be the topic of further research. The association of multibacillary leprosy with migration indicates healthcare access may be an obstacle to early diagnosis among before-diagnosis migrants, which may also be related to the high mobility of this group.

Keywords: social determinants, migration, leprosy, poverty, infectious disease, Brazil

3.2 Introduction

Reasons for migration are many, and employment opportunities and access to better infrastructure, such as healthcare and education, can attract migrants from other areas (UNDP, 2010; Rayp, 2010), while the socioeconomic environment, including poor job opportunities and low wages (Rayp, 2010; IOM, 2008; Ackah & Medvedev, 2010; Golgher, Rosa, & Araujo, 2005) influence the decision to migrate from the place of origin. This is especially reflected in rural to urban population movement. In Brazil, migration has historically been stimulated by strong disparities between poor rural areas in the northeast of the country and large urban centers, a pattern typical of migration flow throughout Latin America (IOM, 2005). Recently, there has been a shift in migration dynamics toward rural in-migration (Golgher, Rosa, & Araujo, 2008) resulting from opportunities in civil development projects and agricultural expansion. National policies and regional economic disparities and conditions can influence the direction and duration of migration (Aagaard-Hansen, Nombela & Alvar, 2010), and temporary or circular patterns (Dewind & Holdaway, 2008; Beguy, Bocquier & Zulu, 2010; Deshingkar, 2008).

A complex relationship exists where low socioeconomic status and poor education influence job skills and employment options, creating urgency for movement, particularly to urban areas creating uncontrolled growth around city perimeters. Poverty and biological vulnerability converge in crowded and substandard housing in areas lacking basic sanitary conditions, access to clean water and other utilities, factors that are also associated with leprosy transmission (Kerr-Pontes, et al., 2004; Sales et al., 2011). These crowded living conditions that include close proximity to individuals with leprosy, particularly multibacillary leprosy, increase risk for infection in comparison to other social contacts (Sales, et al., 2011; Fine, et al., 1997; Richardus, et al., 2005). In Brazil, household contact monitoring is part of the national leprosy surveillance strategy, as is monitoring leprosy among children as an indicator of ongoing active transmission (Brasil MoH, 2010[a]).

Understanding leprosy transmission dynamics is important for insight into how population movement complicates disease control (Aagaard-Hansen, Nombela & Alvar, 2010; Watts, 2008). As World Health Organization (WHO) strategies increasingly move toward greater control and elimination of NTDs, a focused examination of factors associated with migration in those affected by the disease is necessary to better integrate interventions aimed at disease control and elimination. This study has the goal of supporting the Brazil Ministry of Health, Leprosy Control Programs in providing services for migrating populations. The study was designed with the objective of

identifying demographic, socioeconomic, health-service related and clinical factors associated with migration before and after diagnosis with leprosy in an affected population.

3.3 Materials and Methods

3.3.1 Study Design and Data Collection

This cross-sectional study was designed as operational research to provide evidence for improvement to the national and state leprosy control programs. All municipalities included are located in a major endemic cluster identified by the Brazilian Ministry of Health as high-risk areas for leprosy (Penna, Gross, Rocha & Penna, 2010).

3.3.2 Study Area and Population

Tocantins, the newest Brazilian state located in the north region, is a leprosy hyperendemic area with the highest incidence in Brazil (88.54/100,000 inhabitants in 2009) (Brasil MoH, 2010[b]). With one of the fastest growing agriculture-based economies, Tocantins attracts labor migration with more than one third of the population from a different state and more than one half born in different municipalities (IBGE, 2007; IBGE, 2008).

The target population included all new leprosy cases diagnosed between 2006-2008, who were living in endemic municipalities. Individuals living outside of the cluster, those with mental illness or other characteristics that hindered interviews were excluded. Relapsed leprosy cases and those who died after diagnosis were also not included.

3.3.3 Data Collection

Municipality Health Secretariats were informed by the Tocantins State Health Secretariat about the study and field visits were coordinated for data collection. The study population was identified through the database of the National Information System for Notifiable Diseases (*Sistema de Informação de Agravos de Notificação* – SINAN). Patients were invited through Community Health Agents to participate in the study and to be interviewed at the local health care center. Home visits accompanied by local Community Health Agents were performed when individuals did not present at the health care center.

Data collection was conducted between September and December 2009. Clinical data were collected from patients' charts. All other variables, including information on migration, were investigated by interview using structured-questionnaires. Data collection forms were composed

of six groups of variables, and information on migration itself: 1) Socio-demographics (sex, age, marital status, education , employment); 2) Housing/Economic variables (household density, household income, area of residence, utility access; 3) Disease-related variables (clinical form of the disease, operational classification, grade of disability at diagnosis; 4) health services variables (visits by community health worker, access to health services); 5) migration variables (length of time at residence, migration before and after diagnosis; and 6) attitudes and reported practices regarding leprosy and its cure. For detailed information on migration, study participants were asked for the municipality and state of their birth, where they had lived during the five years prior to diagnosis, and whether they had moved after diagnosis.

3.3.4 Data Analysis

Bivariate analysis using Fisher's exact test was conducted in which socio-demographic, economic, clinical, health service-related and attitudes/practices variables were compared between migrants with leprosy and non-migrant residents with leprosy (see Appendix for complete results). These variables were investigated for their association with three different outcome (migration) variables: 1) migration after birth, defined as municipality of birth different from current municipality of residence; 2) migration during five years prior to leprosy diagnosis; and 3) migration after diagnosis. Migration after birth provided a baseline for any lifetime migration, while migration before diagnosis was limited to the average five year latency period for leprosy onset, which is also the current standard in the Brazilian Census survey and reduces recall bias in the survey. As migrant multi-stage migration was also considered, we allowed for non-exclusivity between the three migration outcomes being investigated in the bivariate analysis.

Odds ratios and their respective confidence intervals at 95% were calculated. Theoretically meaningful confounders (age, income, gender and education) were investigated in the bivariate analysis by determining their association ($p<0.05$) with the three migration variables. Only age was a potential confounder. Income was not associated with the three migration outcomes and education was no longer significant among birth migrants after controlling for age. As internal migration is equally distributed between males and females in Brazil (IBGE, 2010), and the sample is also equally distributed between males and females, gender was not believed to present confounding bias. Additionally, only one of the migration outcomes in the bivariate analysis was significantly associated with gender.

A separate multivariate logistic regression analysis was conducted for each variable found to be significant in bivariate analysis with a p-value <0.05 controlling for age. Adjusted odds ratios for the association of migration before diagnosis and after diagnosis migration outcomes compared to non-migrant residents were calculated.

Data were entered twice, using Epi Info software version 3.5.1 (Centers for Disease Control and Prevention, Atlanta, USA) and cross-checked for entry-related errors. Shapiro-Wilk test and histograms were used to assess normality. Data analysis was conducted using STATA version 11 (Stata Corporation, College Station, USA).

3.3.5 Ethics

The study was approved by the Ethical Review Board of the Federal University of Ceará (Fortaleza, Brazil) and by the Ethical Review Board of Lutheran University of Palmas (Palmas, Brazil). Permission to perform the study was also obtained by the Tocantins State Health Secretariat, the State Leprosy Control Program and the municipalities involved. Informed written consent was obtained from study participants after explaining the objectives of the study. To avoid any harm, strict confidentiality was kept, and the diagnosis was not revealed to others, including family members. Interviews were conducted in private. In the case of minors, consent was obtained from a caretaker.

3.4 Results

The sample was selected from 2160 individuals diagnosed with leprosy between 2006 and 2008. A total of 1074 individuals from 79 municipalities were included in the analysis. One municipality did not diagnose any cases of leprosy during the study period, and three municipalities had few cases (n=12) which were not included due to non-consent or because they could not be located. Of those who were not interviewed, 11 were not confirmed leprosy cases, were unable to attend due to illness/hospitalization, inebriation, and incarceration (n=15), could not be located at the given address (n=35), were not known at the healthcare center (n=23), lived in a remote area (n=23), moved after diagnosis (n=269), or were otherwise not at home/working/traveling (n=469) despite multiple attempts, some did not attend the scheduled interviews (n=210) and 31 refused to participate. These individuals were excluded from the study.

Of the total 1074 individuals, 555 (51.7%) were males and 519 (48.3%) females, ranging in age from 5 to 98 years of age (mean = 41.8 year; standard deviation: 19.01). There were 82 children under 15

(7.6%). Nearly half of the individuals (514; 47.9%) were working at least part time/temporary, 162 (15.1%) were unemployed, 178 (16.6%) retired and 230 (21.4%) engaged otherwise, most notably as students 127 (11.8%) or housewives 78 (7.3%). About one in five (n=240, 22.4%) was illiterate and 190 (17.8%) completed a high school education or more. The mean monthly household income was R$ 757 (≈$440), and nearly one-third (n=299, 28.5%) were living on less than the minimum wage per month.

Overall, 426 (42.1%) were classified with multibacillary leprosy at the time of diagnosis, the majority having Grade 0 disability at diagnosis (n=566, 75.4%), followed by Grade I (n=155, 20.6%) and Grade II (n=30, 4.0%). The clinical form of diagnosis was primarily indeterminate (n=332, 38.3%), followed by borderline (n=255, 29.5%), tuberculoid (n=185, 21.4%) and lepromatous leprosy (n=94, 10.9%).

In terms of migration, 800 (76.2%) individuals interviewed migrated at some point in time after birth; 179 (16.7%) were migrants in the five years prior to diagnosis; and 38 (3.6%) migrated after diagnosis. Children also were among those migrating, and comprised 4.5% of those migrating before diagnosis (n=8) and 8.5% after diagnosis (n=19). In total, nearly one fifth (n=199, 18.6%) of those interviewed lived in a different municipality or state five years prior and/or after diagnosis. Migration in the endemic cluster in Tocantins (43.9%, n=76) and migration residence in other states (45.1%, n=78) comprised the majority of population movement before diagnosis. Only 17.3% of migrants resided in non-endemic municipalities in Tocantins during the five years prior to diagnosis. After diagnosis, 73.7% moved within Tocantins, 57.9% to endemic areas of the state. Twenty six percent of those who migrated after diagnosis moved to other states.

3.4.1 Factors associated with migration in the five years before diagnosis

In bivariate analysis age (30-44), poverty, and residence 10 years or less were associated with migration before diagnosis with leprosy (Appendix 1). Logistic regression, controlling for age, identified poverty and clinical variables associated with migration before diagnosis with leprosy. The migrants were more likely to lack access to electricity, public water, and waste management, all indicators of poverty in Brazil. Migrants were also significantly less likely to live in a brick home compared to non-migrant residents, with significantly less time living in their current place of residence (10 years or less). Migrants before diagnosis were also more likely to have multibacillary form of leprosy compared to non-migrant residents with leprosy (Table1).

3.4.2 Factors associated with migration after diagnosis

After diagnosis, residence in the current household 5 years or less and before diagnosis migration was associated with migration (Appendix 1). Migration after diagnosis was associated with key demographic factors after adjusting for age (Table 2). Males were more likely to migrate than females. Also, residence at current household 5 years or less and before diagnosis migration was significantly associated with migration.

3.5 Discussion

Migration can complicate disease control when infected and susceptible people move between endemic and non-endemic areas. Environmental and social factors can influence migration, while health outcomes can be affected by the conditions at locations where movements take place.

In this study, many socio-demographic, clinical, health service and migration variables were investigated. After adjusting for age, a confounding factor for leprosy and migration, key demographics, poverty, factors associated with migration, and multibacillary form of leprosy remained significant for those who migrated before leprosy diagnosis, while only factors related to migration remained associated after diagnosis. Contrary to our expectations, migrant accounts of health service access and stigma did not appear to be associated with migration, although advanced disease expression indicated a delay in diagnosis.

A culture of migration was observed among those affected by leprosy in Tocantins, with more than three-fourths having ever migrated and nearly one-fifth within the last five years. We also found that after diagnosis migration was significantly associated with prior migration, consistent with findings in other studies (Hossain, 2001). Migration can additionally place resident populations at risk, and in Brazil migration has been considered as a possible explanation for diseases, such as leishmaniasis, schistosomiasis and Chagas disease, that have moved into previously non-endemic areas (Aagaard-Hansen, Nombela & Alvar 2010; Watts, 2008; Ximenes, Southgate, Smith, & Neto, 2000; Kloos,et al., 2010; Drummond & Marcopito, 2006). We found that much of the migration in the five years prior to diagnosis was within the endemic cluster in Tocantins and also other states, primarily neighboring Maranhão and Pará. From Maranhão, migration was largely from Imperatriz, while in Pará, Conceição do Araguaia and São Geraldo were principal sites of prior residence. These three municipalities are located in hyperendemic areas for leprosy (Penna, et al., 2010). Considerably fewer migrants resided in municipalities in Tocantins outside of the endemic cluster during the five years prior to diagnosis. The majority of after diagnosis migrants moved to other

endemic areas in Tocantins. Presence of leprosy among children who migrated, highlights active transmission in these regions.

3.5.1 Key Demographics

Migration is most often associated with the movement of young adults, typically males between the ages of 20 and 35, who migrate for employment (Ackah & Medvedev, 2010; Beguy, et al., 2010; Hossain, 2001; Barbieri, Carr & Bilsburrow, 2009). We found that migration of leprosy-affected individuals was significantly associated with being male after diagnosis, and overall, migrants were slightly older than the younger age-set typical of migration globally. This age pattern is consistent with population movement in Brazil (Golgher, et al., 2008). Migration increased with age and dropped only slightly among those aged 60 or older. Migration of the older age groups may be the result of historical population movement in the Northeast region from rural areas to urban centers due to industrialization (Fischlowitz, 1969) and periods of severe drought (Barbieri, et al., 2010). This trend has continued into recent decades and may be a factor hindering disease control (Ximenes, et al., 2000; Montenegro, Werneck, Kerr-Pontes & Feldmeier, 2004). This historic population movement has contributed to poor sanitation and overcrowding in areas of uncontrolled urbanization in Brazil.

Nearly half of those with leprosy were employed regardless of whether they were migrants or non-migrant residents. This indicates that stigma as a result of leprosy does not appear to be a significant factor for securing employment. In a previous study, stigma was also found to be an insignificant factor in changing residence (Murto, et al., 2012) and was a minor issue in therapy interruption (Chichava et al., 2011).

3.5.2 Poverty

NTDs are known to be associated with low socioeconomic status, often resulting in poor health (Aagaard-Hansen & Chaignat, 2010). While migration typically provides an opportunity to lift individuals out of poverty over time (Deshingkar, 2008), the initial decision to migrate is often a strategy to mitigate poverty, and migration also supplements income at critical moments (IOM, 2005; Dewind & Holdaway, 2008; Deshingkar, 2008; Hossain, 2001). Unfortunately, these decisions can have further repercussions, negatively affecting health as result of poor housing, sanitation and other socio-environmental conditions (Aagaard-Hansen & Chaignat, 2010) closely associated with poverty.

While low household income was not specifically associated with migration among leprosy-affected individuals in Tocantins, indirect indicators of poverty were associated with migration in this study. This was particularly relevant for those who migrated prior to diagnosis compared to non-migrant residents with leprosy. Absence of trash collection and access to public water, or not living in a house made of brick were all associated with those who migrated in the five years before diagnosis. Previous studies have found that non-migrants typically have a higher socioeconomic status than migrants (UNDP, 2009; Perlman, 2007). Thus, migrants and non-migrant residents with leprosy might be exposed to low socioeconomic levels and poor living standards differentially.

Migration after diagnosis had no association with indicators of poverty. Socioeconomic factors influence the initial decision to migrate, and these variables may change once migration has taken place (Hossain, 2001). Although our study only considered socioeconomic variables and utility access after leprosy diagnosis, access to better amenities, such as electricity, has been associated with a reduction in further migration (Beguy, et al., 2010).

3.5.3 Migration, Leprosy and Healthcare Access

In Brazil, the most prominent form of leprosy is borderline (41.5%), followed by lepromatous (23.2%), tuberculoid (19.6%) and indeterminate (15.6%) leprosy (Arantes, Garcia, Filipe, Nardi & Paschoal, 2010). One-fourth of leprosy cases in Brazil in 2010 were classified as multibacillary (MB)(Brasil MoH, 2010[c]), which includes midborderline, borderline lepromatous, and lepromatous forms of leprosy. In Tocantins, before diagnosis migration was associated with the more severe multibacillary classification. MB has a high risk for transmission (Fine et al., 1997; Moet, Pahan, Schuring, Oskam & Richardus, 2006), while paucibacillary (PB) forms have a low transmission risk among those in close contact with individuals with leprosy (Halder, Mundle, Bhadra, & Saha, 2001). The odds of MB among before diagnosis migrants were 1.5 times higher than non-migrant residents with leprosy. Access to early diagnosis may in fact be a consideration for this group.

While poor access to health services has been found to be a motivating factor for migration (UNDP, 2010), our findings show minimal after diagnosis migration. This is perhaps a response to maintain treatment at the place of diagnosis, within primary health care. Another study of the same population found that lifestyle changes (home ownership, family, better living/neighborhood conditions) were the primary reasons for changing residences, with less than 5% moving for the purpose of seeking diagnosis or treatment (Murto, et al., 2012). The decentralization of health services for leprosy diagnosis and treatment to community health centers throughout Brazil has likely played an important role in this regard.

There was no significant difference in the time from symptom onset to diagnosis among migrants in Tocantins compared to non-migrants. While there is some speculation that migrants are less likely to use health facilities (UNPF GSO, 2006), other research has shown that availability of health services even among the displaced, has contributed to improved health (WHO, 2000). Health services were sought by up to a fifth of those that migrated prior to diagnosis and by one fourth of those who migrated after diagnosis, yet migrants did not have significantly more difficulty in accessing health centers or community health workers than non-migrants. Despite this positive information, the prevalence of advanced MB leprosy among those who migrated in the five years prior to diagnosis suggests a delay in diagnosis or poor knowledge of symptoms associated with leprosy. Given the progressive evolution of MB leprosy, lack of access to health care and poor attention to infection could occur over multiple movements.

3.5.4 Limitations

Like many other cross-sectional studies, our study is subject to several limitations. First, the cross-sectional design made causal and temporal relationships difficult to establish. Migration may cause certain behaviors/characteristics, and also be caused by these same variables. For this reason, we focused on associations rather than causes in the analysis and discussion of data.

Despite being a population-based study in a hyperendemic area, we only included in-migrants to municipalities. Anyone moving outside of the cluster during the defined study period was excluded, which limited additional knowledge in regards to after diagnosis migration.

This study was performed in 79 municipalities with a broad geographical range. While this increases the representativeness of our findings, approximately 50% of the population could not be reached. Many individuals were not encountered even after multiple home visits or did not attend scheduled interviews. Some individuals moved to another city outside the cluster. Incomplete patients' charts and subsequent missing data hampered analysis in some cases. Non-participation bias may have played a role. We aimed at reducing bias by rigorously planning field visits and integrating local primary health care professionals and the State and Municipal Leprosy Control Programs during field work for the present study.

A final limitation is that socioeconomic data were collected after migration. Other researchers have noted the difficulty in differentiating between migrant and non-migrant households because socioeconomic factors may influence the decision to migrate, and these same variables may change

once migration has taken place (Hossain, 2001). In addition, current economic conditions do not account for latency in leprosy, which can manifest up to decades after exposure.

3.6 Conclusions

This is the first major systematic study exploring migration in leprosy-affected individuals. In this population in a highly endemic area factors associated with poverty were associated with migration.

Attention to reaching possibly infected and highly mobile populations in Brazil should be a focus to prevent further transmission of the disease and development of disabilities among those infected. This is particularly important in endemic states, with high in- and between- municipality migration, such as Tocantins. Attention to low-income rural areas should take into account difficulties with transportation. Ease of healthcare access provides the opportunity to reduce disability and increase leprosy control.

Newly emerging trends of circular migration provide an opportunity to investigate these patterns and their relationship to disease transmission and migration flow between community of origin and destination and should be considered for future studies.

3.7 Acknowledgments

We thank Adriana Cavalcante Ferreira, Suen de Oliveira Santos and the entire team of the State Health Secretariat of Tocantins. Collaboration of the Municipalities' Health Secretariats and Primary Health Care Centers is acknowledged. We are also grateful to all patients that kindly agreed to participate in the study. Special thanks to Professor Marcel Tanner, Director of the Swiss Tropical and Public Health Institute (SwissTPH) for insightful review and guidance. The research project "MAPATOPI" was financed by the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) and the Department of Science and Technology of the Brazilian Ministry of Health (DECIT), Brazil. JH is research fellow from CNPq. OAC received a "PEC-PG" scholarship from CNPq, ARO a Master's scholarship from Fundação Cearense de Apoio ao Desenvolvimento Científico e Tecnológico (FUNCAP), and CHA a PhD scholarship from Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), Brazil.

Table 3.1: Adjusted Odds Ratios of factors significantly associated with before diagnosis migration compared to non-migrant residents with leprosy, controlling for age

	Before Diagnosis Migration	
	Adjusted OR (95% CI)	**p value**
Socio-demographic variables		
No Public Water	1.65 (1.12 – 2.43)	0.012*
No Trash Service	1.70 (1.2 – 2.41)	0.003*
Living in home not brick	1.57 (1.01 – 2.32)	0.022*
Diagnosis Multibacillary	1.55 (1.09 – 2.19)	0.014*
Migration Variables		
Yrs at current residence 0 – 5 years	23.38 (10.1 – 54.09)	<0.0001*
Yrs at current residence 6 – 10 years	6.77 (2.73 - 16.75)	<0.0001*

* Significant at 95% (p<0.05)

Table 3.2: Adjusted Odds Ratios of factors significantly associated with after diagnosis migration compared to non-migrant residents with leprosy, controlling for age

	After Diagnosis Migration	
	Adjusted OR (95% CI)	**p value**
Socio-demographic variables		
Male sex	2.87 (1.38 – 5.99)	0.005*
Migration Variables		
Before Diagnosis Migration	7.74 (3.89 – 15.37)	<0.0001*
Yrs at current residence 0 – 5 years	8.69 (2.57 –29.32)	<0.0001*

* Significant at 95% (p<0.05)

3.8 References

Aagaard-Hansen, J., & Chaignat, C. (2010). Neglected tropical diseases: equity and social determinants. In E. Blas, & A. S. Kurup (Eds.), *In Equity, social determinants and public health programmes.* Geneva: World Health Organization (WHO).

Aagaard-Hansen, J., Nombela, N., & Alvar, J. (2010). Population movement: a key factor in the epidemiology of neglected tropical diseases. *Trop Med Int Health*, 1281-1288.

Ackah, C., & Medvedev, D. (2010). *Internal migration in Ghana: Determinants and welfare impacts.* Washington, D.C.: World Bank/West Africa Poverty Reduction and Economic Management Unit (World Bank Policy Research Working Paper Series, 5273).

Arantes, C., Garcia, M., Filipe, M., Nardi, S., & Paschoal, V. (2010). Avaliação dos serviços de saúde em relação ao diagnóstico precoce da hanseníase. *Epidemiol. Serv. Saúde, 19*(2), 155-164.

Barbieri, A., Carr, D., & Bilsburrow, R. (2009). Migration within the frontier: The second generation colonization in the ecuadorian Amazon. *Popul Res Policy Rev, 28*, 291-320.

Barbieri, A., Domingues, E., Queiroz, B., Ruiz, R., Rigottin, J., Carvalho, J., & Resende, M. (2010). Climate change and population migration in Brazil's Northeast: scenarios for 2025-2050. *Popul Environ, 31*, 344-70.

Beguy, D., Bocquier, P., & Zulu, E. (2010). Circular migration patterns and determinants in Nairobi slum settlements. *Demographic Research, 23*, 549-86.

Brazil, MoH. (2010[a]). *Aprova as Diretrizes para Vigilância, Atenção e Controle da hanseníase.* Portaria N[o] 3.125. Retrieved from http://portal.saude.gov.br/portal/arquivos/pdf/portaria_n_3125_hanseniase_2010.pdf

Brazil, MoH. (2010[b]). *Indicadores de morbidade e factores de risco. Taxa de prevalencia de hanseniase.* Retrieved from http://tabnet.datasus.gov.br/cgi/deftohtm.exe?idb2011/d0206.def

Brazil MoH. (2010[c]). *Registro ativo: número e percentual, Casos novos de hanseníase: número, coeficiente e percentual, faixa etária, classificação operacional, sexo, grau de incapacidade, contatos examinados, por estados e regiões.*

Chichava, O.A., Ariza, L., Oliveira, A.R., Ferreira, A.C., da Silva, L.F., Barbosa, A.N., Ramos, Jr., A.N., & Heukelbach, J. (2011). Reasons for Interrupting Multidrug Therapy Against Leprosy. *Leprosy Review, 82*, 78-9.

Costa, C., Pereira, H., & Araujo, M. (1990). Visceral leishmaniasis epidemic in Piaui state, Brazil 1980-1986. *Rev Saude Publica, 24*(5), 361-72.

Deshingkar, P. (2008). Circular Internal Migration and Development in India. In J. DeWind, & J. Holdaway (Eds.), *Migration and Development Within and Across Borders: Reserach and Policy Perspectives on Internal and International Migration* (pp. 161-187). Geneva: IOM and SSRC.

DeWind, J., & Holdaway, J. (2008). Internal and International Migration and Development: Research and Policy Perspectives. In *Migration and Development Within and Across Borders: Reserach and Policy Perspectives on Internal and International Migration* (pp. 15-26). Geneva: IOM and SSRC.

Drumond, J., & Marcopito, L. (2006). Internal migration and distribution of chagas disease mortality, Brazil 1981-1998. *Cad Saude Publica, 22*, 2131-40.

Fine, P., Sterne, J., Ponninghaus, J., Bliss, L., Saul, J., Chihuana, A., Munthali, M. & Warndorff, D.K. (1997). Household and dwelling contact as risk factors for leprosy in Northern Malawi. *Am J Epidemiol, 146*(1), 91-102.

Fischlowitz, E., & Engel, M. (1969). Internal Migration in Brazil. *International Migration Review, 3*(3).

Golgher A, Rosa CH, Araujo Jr AF. The determinants of migration in Brazil In: Proceedings of the 33rd Brazilian Economics Meeting; Niteroi, RJ: ANPEC; 2005. p. 1-20.

Golgher, A., Rosa, C., & Araujo Jr, A. (2008). Determinants of migration in Brazil: Regional Polarization and Povety Traps. *Papeles de Poblacion*(56), 135-171.

Halder, A., Mundle, M., Bhadra, U., & Saha, B. (2001). Role of paucibacillary leprosy in the transmission of disease. *Indian J Leprosy, 73*(1), 11-15.

Hossain, M.Z. (2001). *Rural-urban migration in Bangladesh: a micro-level study*. Paper presented at XXIV International Union for the Scientific Study of Population (IUSSP) General Population Conference; Aug 20-24. Salvador, BA Brazil; 2001. http://www.archive-iussp.org/Brazil2001/s20/S28_P02_Hossain.pdf.

Instituto Brasileiro de Geografia e Estatística (IBGE). (2007). *Pesquisa Nacional por Amostra de Domicílios (PNAD).* Retrieved from http://www.ibge.gov.br.

Instituto Brasileiro de Geografia e Estatística (IBGE). (2008). *Pesquisa Nacional por Amostra de Domicílios (PNAD).* Retrieved from http://www.ibge.gov.br.

Instituto Brasileiro de Geografia e Estatística (IBGE). (2010). *Results of Population Census 2010*. Retrieved from ftp://ftp.ibge.gov.br/Censos/Censo_Demografico_2010/Nupcialidade_Fecundidade_Migracao/tab1_3.pdf.

International Organization for Migration (IOM). (2005). *Internal Migration and Development: A Global Perspective.* eds. Deshingkar P, Grimm S.

International Organization for Migration (IOM). (2008). *World Migration 2008: Managing Labour Mobility in the Evolving Global Economy.* Geneva: IOM.

Kerr-Pontes, L.R.S., Barreto, M.L., Evangelista, C.M.N., Rodrigues, L.C., Heukelbach, J., & Feldmeier, H. (2006). Socioeconomic, environmental and behavioral risk factors for leprosy in North-east Brazil: results of a case-control study. *Int J Epidemiol, 35*(4), 994-1000.

Kerr-Pontes, L.R.S., Montenegro, A.C., Barreto, M.L., Werneck, G.L., & Feldmeier, H. (2004). Inequality and leprosy in Northeast Brazil: an ecological study. *Int J of Epid, 33*, 262-269.

Kloos, H., Correa-Oliveira, R., dos Reis, D.C., Rodriques, E., Monteiro, L.A.S., & Gazzinelli, A. (2010). The role of population movement in the epidemiology and control of schistosomiasis in Brazil: a preliminary typology of population movement. *Mem Inst Oswaldo Cruz, 105*(4), 578-86.

Magalhães M.C.C., & Rojas L.I. (2007). Spatial Differentiation of Leprosy in Brazil. *Epidemiologia e Serviços de Saúde 2007*, 16(2), 75-84.

Moet, F., Pahan, D., Schuring, R., Oskam, L., & Richardus, J. (2006). Physical distance, genetic relationship, age and leprosy classification are independent risk factors for leprosy in contacts of patients with leprosy. *J of Infec Dis, 193*, 346-53.

Montenegro, A., Werneck, G., Kerr-Pontes, L., & Feldmeier, H. (2004). Spatial analysis of the distribution of leprosy in the state of Ceara, Northeast Brazil. *Mem Inst Oswaldo Cruz, 99*(7), 683-86.

Murto, C., Ariza, L., Oliveira, A.R., Chichava, O.A., Alencar, C.H., da Silva, L.R.M., Tanner, M., & Heukelbach, J. (2012). Motives and determinants for residence change after leprosy diagnosis, central Brazil. *Leprosy Review, 83*(1), 16-23.

Penna, M.L.F., Gross, M.A.F., Rocha, M.C.N., & Penna, G.O. (2010). Chapter 12: Comportamento epidemiológico da hanseníase no Brasil. In *Saúde Brasil 2009: uma análise da situação de saúde e da agenda nacional e internacional de prioridades em saúde (pp. 295-318)*. Brasilia, DF: Ministério da Saúde, Secretaria de Vigilância em Saúde.

Perlman, J. (2007). *Globalization and the Urban Poor.* World Institute for Development Economics Research, World Institute for Development Economics Research. New York: United Nations University.

Rayp, G., Ruyssen, I. (2010) *Africa on the move: an extended gravity model of intra-regional migration.* Paper presented at Migration, A World in Motion: A multinational Conference on Migration and Migration Policy, Association for Public Policy Analysis and Management (APPAM); February 18-20. Maastricht, Netherlands; 2010 . Retrieved from http://umdcipe.org/conferences/Maastricht/conf_papers/Papers/Africa_on_the_Move.pdf .

Richardus, J., Meima, A., van Marrewijk, C., Croft, R., & Smith, T. (2005). Close Contacts with Leprosy in Newly Diagnosed Leprosy Patients in a high and low endemic area: Comparison between Bangladesh and Thailand. *Int J Lep Rev, 73*(4), 249-257.

Sales, A., Leon, A., Duppre, N., Hacker, M., Nery, J., Sarno, E., & Penna, M.L.F. (2011). Leprosy among patient contacts: A multilevel study of risk factors. *PLOS NTD, 5*(3), e1013.

UNDP. (2009). *Overcoming barriers: Human mobility and development.* United Nations Development Program. New York: UNDP.

UNDP. (2010). *Mobility and Migration: A Guidance Note for Human Development Report Teams*. United Nations Development Program. New York: UNDP.

UNPF, GSO. (2006). *The 2004 Vietnam Migration Survey: Migration and Health.* Hanoi.

van Beers, S., Hatta, M., & Klatser, P. (1999). Patient contact is the major determinant in incident leprosy: implications for future control. *Int J Lepr Other Mycobact Dis, 67*(2), 119-28.

Watts, S. (2008). *The Social Determinants of Schistosomiasis.* Retrieved from TropIKA.net: http://www.tropika.net/review/051114-Schistosomiasis_Social_Determinants/article.pdf

WHO. (2000). *World Health Report 2000: Health Systems: Improving Performance.* World Health Organization, Geneva.

WHO. (2008). *Closing the gap in a generation: health equity through action on the social determinants of health. Final Report.* Commission on Social Determinants of Health (CSDH). Geneva: World Health Organization.

Ximenes, R., Southgate, B., Smith, P., & Neto, L. (2000). Migration and urban schistosomiasis, the case of Sao Lourenco da Mata, Northeast of Brazil. *Rev Inst Med Trop S. Paulo, 42*(4), 209-17.

Appendix **Chapter 3**

Table 3A.1: Bivariate analysis of factors associated with migration before and after leprosy diagnosis ††

	After Birth Migration				Migration Before Diagnosis				After Diagnosis Migration			
	Total† n=1050	Positive n (%)	OR (95% CI)	p value	Total† n=1071	Positive n (%)	OR (95% CI)	p value	Total† n=1062	Positive n (%)	OR (95% CI)	p value
Socio-demographic variables												
Sex												
Male	545	413 (75.8)	0.95 (0.71 – 1.28)	0.77	553	102 (18.4)	1.30 (0.93 – 1.82)	0.12	548	28 (5.1)	2.71 (1.26 – 6.32)	0.007*
Female	505	387 (76.6)	Reference		518	77 (14.9)	Reference		541	10 (2.0)	Reference	
Age-groups (years)												
0-14	82	40 (48.8)	Reference		79	8 (10.1)	Reference		80	2 (2.5)	Reference	
15-29	236	135 (57.2)	1.4 (0.82 – 2.4)	0.20	239	52 (21.8)	2.46 (1.09 – 6.30)	0.20	237	10 (4.2)	1.72 (0.35 – 16.44)	0.74
30-44	261	194 (74.3)	3.04 (1.76 – 5.42)	<0.0001*	269	64 (23.8)	2.77 (1.24 – 7.00)	0.01*	267	12 (4.5)	1.84 (0.40 – 17.21)	0.54
45-59	254	224 (88.2)	7.84 (4.23 – 14.54)	<0.0001*	257	30 (11.7)	1.17 (0.50 – 3.10)	0.84	254	12 (4.7)	1.93 (0.42 – 18.13)	0.53
≥60	217	207 (95.4)	21.74 (9.62 – 51.95)	<0.0001*	227	25 (11.0)	1.10 (0.45 – 2.95)	1.00	224	2 (1.0)	0.35 (0.03 – 4.94)	0.28
Education												
Illiterate/Never attended school	231	210 (90.9)	3.86 (2.38 – 6.53)	<0.0001*	240	37 (15.4)	0.88 (0.58 – 1.32)	0.56	236	5 (2.1)	0.52 (0.16 – 1.36)	0.23
Attended school any time	815	588 (72.2)	Reference		827	142 (17.2)	Reference		822	33 (4.0)	Reference	
Work status												
Employed	453	346 (76.4)	Reference		458	79 (17.3)	Reference		455	17 (3.7)	Reference	

Unemployed	155	122 (78.7)	1.14 (0.72 – 1.84)	0.58	162	28 (17.3)	1.00 (0.60 – 1.64)	1.00	161	10 (6.2)	1.71 (0.68 – 4.04)	0.19
Part-time	55	43 (78.2)	1.11 (0.55 – 2.40)	0.87	55	15 (27.3)	1.80 (0.88 – 3.52)	0.09	54	4 (7.4)	2.06 (0.48 – 6.65)	0.26
Retired/pensioner	170	160 (94.1)	4.95 (2.50 – 10.88)	<0.0001*	178	22 (12.4)	0.67 (0.39 – 1.14)	0.08	174	1 (0.6)	0.15 (0.0 – 0.97)	0.03*
Student/housewife/ others	217	129 (59.5)	0.45 (0.32 – 0.65)	<0.0001*	218	35 (16.1)	0.92 (0.58 – 1.44)	0.74	218	6 (2.8)	0.73 (0.23 – 1.97)	0.65
Farm worker (any time in life)												
Yes	413	351 (85.0)	2.38 (1.71 – 3.33)	<0.0001*	427	74 (17.3)	1.09 (0.77 – 1.53)	0.68	423	13 (3.1)	0.80 (0.37 – 1.66)	0.61
No	629	443 (70.4)	Reference		636	103 (16.2)	Reference		632	24 (3.8)	Reference	
Housing- and economic-related variables												
Household month income†††												
≥ 465 R$	736	566 (76.9)	Reference	0.42	298	52 (17.4)	1.06 (0.73 – 1.53)	0.78	299	12 (4.0)	1.14 (0.52 – 2.40)	0.72
<465 R$ (≈270.US$)	289	215 (74.4)	0.87 (0.63 – 1.21)		750	124 (16.5)	Reference		741	26 (3.5)	Reference	
Residence area												
Rural/Settlement	252	194 (77.0)	1.06 (0.75 – 1.51)	0.80	256	53 (20.7)	1.43 (0.98 – 2.06)	0.06	256	12 (4.7)	1.47 (0.67 – 3.08)	0.33
Urban	797	605 (75.9)	Reference		814	126 (15.5)	Reference		805	26 (3.2)	Reference	
Electricity												
No	64	42 (65.6)	0.57 (0.33 – 1.03)	0.049*	64	18 (28.1)	2.05 (1.09 – 3.72)	0.02*	65	3 (4.6)	1.33 (0.25 – 4.40)	0.42
Yes	985	757 (76.9)	Reference		1006	161 (16.0)	Reference		996	35 (3.5)	Reference	

Public waste collection												
No	291	221 (76.0)	0.98 (0.71 – 1.37)	0.93	297	64 (21.6)	1.57 (1.11 – 2.23)	0.01*	295	14 (4.8)	1.54 (0.73 – 3.15)	0.20
Yes	758	578 (76.2)	Reference		773	115 (14.9)	Reference		766	24 (3.1)	Reference	
Public sewer system												
No	120	86 (71.7)	0.76 (0.49 – 1.20)	0.21	123	27 (21.0)	1.47 (0.89 – 2.37)	0.12	122	4 (3.3)	0.90 (0.23 – 2.60)	1.00
Yes	929	714 (76.9)	Reference		947	152 (16.1)	Reference		939	34 (3.6)	Reference	
Public water supply												
No	194	150 (77.3)	1.08 (0.74 – 1.60)	0.71	197	43 (21.8)	1.52 (1.01 – 2.25)	0.44	196	9 (4.6)	1.39 (0.57 – 3.08)	0.40
Yes	856	650 (75.9)	Reference		874	136 (15.6)	Reference		866	29 (3.4)	Reference	
Brick/adobe house construction												
No	192	147 (76.6)	1.03 (0.70 – 1.52)	0.93	197	44 (22.34)	1.57 (1.05 – 2.33)	0.03*	194	6 (3.1)	0.83 (0.28 – 2.06)	0.83
Yes	858	653 (76.1)	Reference		874	135 (15.5)	Reference		868	32 (3.7)	Reference	
Number of rooms/household												
1−2	67	50 (74.6)	0.91 (0.50 – 1.71)	0.77	67	11 (16.4)	0.97 (0.45 – 1.93)	1.00	66	1 (1.5)	0.40 (0.0 – 2.44)	0.51
> 2 rooms	980	749 (76.4)	Reference		1001	168 (16.8)	Reference		993	37 (3.7)	Reference	
Living alone												
1 person	56	52 (92.9)	4.28 (1.55 – 16.44)	0.002*	58	10 (17.2)	1.04 (0.46 – 2.13)	0.86	58	(6.9)	2.11 (0.52 – 6.23)	0.15
> 1 person	993	747 (75.2)	Reference		1012	169 (16.7)	Reference		1003	34 (3.4)	Reference	

Disease-related variables at diagnosis												
Clinical form												
Tuberculoid	182	133 (73.1)	1.04 (0.68 – 1.61)	0.92	185	29 (15.7)	1.00 (0.58 – 1.68)	1.0	185	10 (5.4)	1.81 (0.66 – 4.93)	0.24
Borderline	247	194 (78.5)	1.41 (0.94 – 2.12)	0.10	255	45(17.7)	1.15 (0.72 – 1.82)	0.58	255	9 (3.5)	1.16 (0.41 – 3.22)	0.82
Lepromatous	92	79 (85.9)	2.33 (1.21 – 4.80)	0.01*	94	19 (20.2)	1.36 (0.71 – 2.51)	0.35	94	2 (2.1)	0.69 (0.07 – 3.31)	1.00
Indeterminate	324	234 (72.2)	Reference		331	52 (15.7)	Reference		326	10 (3.1)	Reference	
Operational classification												
Multibacillary	416	335 (80.5)	1.54 (1.12 – 2.11)	0.006*	426	79 (18.5)	1.37 (0.96 – 1.95)	0.07	424	12 (2.8)	0.74 (0.33 – 1.58)	0.48
Paucibacillary	572	417 (72.9)	Reference		583	83 (14.2)	Reference		579	22 (3.8)	Reference	
Disability grade at diagnosis (DG)												
DG II	29	26 (89.7)	2.98 (0.90 – 15.56)	0.08	30	5 (16.7)	1.20 (0.35 – 3.28)	0.79	30	0 (0.0)	-	1.00
DG 0 or I	703	523 (74.4)	Reference		719	103 (14.3)	Reference		717	22 (3.1)	Reference	
Time from symptom onset and sought diagnosis												
> 6 months	271	214 (79.0)	1.24 (0.87 – 1.78)	0.24	276	51 (18.5)	1.16 (0.78 – 1.69)	0.45	274	11 (4.0)	1.07 (0.47 – 2.30)	0.85
≤ 6 months	661	497 (75.2)	Reference		671	110 (16.4)	Reference		667	25 (3.8)	Reference	

Health service-related variables												
Regular home community health worker visit (≤1 mo)												
No	338	267 (79.0)	1.26 (0.91 – 1.75)	0.16	345	59 (17.1)	1.04 (0.73 – 1.48)	0.86	343	15 (4.4)	1.38 (0.66 – 2.80)	0.38
Yes	712	533 (74.9)	Reference		726	120 (16.5)	Reference		719	23 (3.2)	Reference	
Time to reach the health care centre												
> 30 minutes	181	137 (75.7)	0.98 (0.66 – 1.46)	0.92	407	64 (15.7)	0.87 (0.61 – 1.23)	0.45	189	8 (4.2)	1.21 (0.47 – 2.77)	0.67
≤ 30 minutes	850	647 (76.1)	Reference		647	114 (17.6)	Reference		856	30 (3.5)	Reference	
Difficulty reaching health care center												
Yes	201	158 (78.6)	1.19 (0.81 – 1.77)	0.41	209	37 (17.7)	1.07 (0.70 – 1.61)	0.76	207	11 (5.3)	1.70 (0.74 – 3.60)	0.15
No	835	631 (75.6)	Reference		848	142 (16.8)	Reference		841	27 (3.2)	Reference	
Migration												
Migrant after diagnosis												
Yes	-	-	-	-	38	22 (57.9)	7.87 (3.83 – 16.38)	<0.0001*	-	-	-	-
No	-	-	-		1022	152 (14.9)	Reference		-	-	-	
Migrant 5-years prior to diagnosis												
Yes	-	-	-	-	-	-	-	-	174	22 (12.6)	7.87 (3.83 – 16.38)	<0.0001*
No	-	-	-		-	-	-		886	16 (1.8)	Reference	

Time at residence												
0 – 5 years	470	349 (74.3)	0.79 (0.56 – 1.11)	0.18	476	146 (30.7)	25.22 (11.06 – 70.63)	<0.0001*	469	33 (7.0)	8.70 (2.69 – 44.64)	<0.0001*
6 – 10 years	237	183 (77.2)	0.93 (0.61 – 1.41)	0.76	245	27 (11.0)	7.06 (2.79 – 21.2)	<0.0001*	243	2 (0.8)	0.95 (0.8 – 8.40)	1.00
≥ 11 years	340	267 (78.5)	Reference		348	6 (1.7)	Reference		348	3 (0.9)	Reference	
Practices and attitudes												
Sought other health service prior to diagnosis												
Yes	-	-	-	-	181	36 (19.9)	1.29 (.83- 1.96)	0.23	179	10 (5.6)	1.80 (0.76 – 3.90)	0.12
No	-	-	-		886	143 (16.1)	Reference		879	28 (3.2)	Reference	
Hide leprosy diagnosis due of fear of prejudice												
Yes	-	-	-	-	-	-	-	-	1039	38 (3.7)	-	1.00
No	-	-	-		-	-	-		20	0 (0.0)	Reference	
Different behavior from others after diagnosis												
Yes	-	-	-	-	-	-	-	-	157	3 (1.9)	0.48 (0.09 – 1.55)	0.35
No	-	-	-		-	-	-		898	35 (3.9)	Reference	

††† At the time of the survey 1US$ was equivalent to 1.72R$, and R$ 465,- the official minimum wage as set by the Federal Government.

†† After Birth Migration, migration in the five years before leprosy diagnosis and migration after diagnosis

† Data not available for all individuals

* Significant at 95% (p<0.05)

4 Factors Associated with Migration in Individuals Affected by Leprosy, Maranhão, Brazil: An Exploratory Cross-Sectional Study †

Christine Murto (1,2), Charles Kaplan (3),Liana Ariza (4), Karol Schwarz (5), Carlos Henrique Alencar (3), Lea M da Costa (6), Jorg Heukelbach (4,7)*

1. Swiss Tropical and Public Health Institute, Basel, Switzerland
2. University of Basel, Basel Switzerland
3. School of Social Work, Hamovitch Center for Science in the Human Services, University of Southern California
4. Department of Community Health, School of Medicine, Federal University of Ceará, Fortaleza, Brazil
5. School of Medicine, University of Cologne, Cologne, Germany
6. State Leprosy Control Program; State Health Secretariat of Maranhão, Sao Luis, Brazil
7. Anton Breinl Centre for Public Health and Tropical Medicine; School of Public Health, Tropical Medicine and Rehabilitation Sciences, James Cook University, Townsville, Australia

*** Corresponding author**: Prof. Jorg Heukelbach, Departamento de Saúde Comunitária, Faculdade de Medicina, Universidade Federal do Ceará, Rua Professor Costa Mendes 1608, 5. andar, Fortaleza CE, 60430-140, Brazil. Phone: ++55-85-33668045; Fax: ++55-85-33668050. Email: heukelbach@web.de

† This publication is part of the MAPATOPI study (an interdisciplinary project providing evidence for improving the Brazilian leprosy control program), co-financed by the Brazilian Research Council (CNPq) and the Department of Science and Technology of the Brazilian Ministry of Health (DECIT).

This article has been published in

Journal of Tropical Medicine Volume 2013, Article ID 495076
Accepted for publication August 9, 2013

4.1 Abstract

In Brazil, leprosy is endemic and concentrated in high-risk clusters. Internal migration is common in the country, and may influence leprosy transmission and hamper control efforts. We performed a cross-sectional study with two separate analyses evaluating factors associated with migration in Brazil's Northeast: one among individuals newly diagnosed with leprosy, and the other among a clinically unapparent population with no symptoms of leprosy for comparison. We included 394 individuals newly diagnosed with leprosy, and 391 from the clinically unapparent population. Of those with leprosy, 258 (65.5%) were birth migrants, 105 (26.6%) were past five year migrants; 43 (10.9%) were circular migrants. In multivariate logistic regression, three independent factors were found to be significantly associated with migration among those with leprosy: 1) alcohol consumption; 2) separation from family/friends; 3) difficulty reaching the healthcare facility. Separation from family/friends was also associated with migration in the clinically unapparent population. The health sector may consider adapting services to meet the needs of migrating populations. Future research is needed to explore risks associated with leprosy susceptibility from life stressors, such as separation from family and friends, access to healthcare facilities and alcohol consumption to establish causal relationships.

4.2 Introduction

Migration has been identified as one of the social determinants influencing transmission dynamics of Neglected Tropical Diseases (NTDs) (WHO, 2008; Aagard-Hansen, Nombela, & Alvar, 2010). In fact, population movement can introduce new diseases when infected migrants move from endemic to non-endemic areas (Watts, 2008; Aagaard-Hansen, Nombela, & Alvar, 2010). As strategies of disease control become increasingly important to meet World Health Organization (WHO) standards, a more thorough approach is needed to investigate migration as a risk factor for disease and determine factors associated with migration in a local context.

Migration can influence transmission of NTDs when circumstances influence conditions and risks associated with disease transmission, particularly among the poor who are disproportionately affected (Allotey, Reidpath, & Pokhrel, 2010). Environmental aspects as a consequence of poverty, such as poor sanitation and overcrowded substandard housing in areas of uncontrolled urbanization (Perlman, 2007; Watts, 2008), as well as lifestyle stressors (Bhugra, 2004; Lu, 2010) and behaviors associated with migration (Borges, et al., 2011; Garcia, 2008) can increase susceptibility to infection and disease risk. Many of these factors have also been associated with leprosy transmission (Kerr-Pontes , Montenegro, Barreto, Werneck, & Feldmeier, 2004; Sales A. , et al., 2011).

It is estimated that 740 million people are internal migrants, a common condition of life in many low and middle income countries (UNDP, 2009). The reasons for migration are numerous, and include drivers such as political conflict (Rayp & Ruyssen, 2010), disaster and environmental change (WHO, 2002; Manderson, Aagaard-Hansen, Allotey, Gyapong, & Sommerfeld, 2009), as well as socioeconomic determinants (Rayp & Ruyssen, 2010; Ackah & Medvedev, 2010). While migration is often a strategy to mitigate poverty (Deshingkar, 2008), it is also a means to acquire capital for land, housing and other opportunities (Lindstrom & Lauster, 2001; Murto, et al., 2012). Movement can be a strategy to realize a higher standard of living, access to better employment, education and health service infrastructure, primarily between resource poor rural areas and urban centers (Deshingkar, 2008; Perlman, 2007; Rayp & Ruyssen, 2010). These factors can influence short-term temporary or circular migration (Deshingkar, 2008), or permanent relocation (Ackah & Medvedev, 2010).

In Brazil, migration has historically taken place between poor rural areas in the northeast to large urban centers (Golgher, Rosa, & Araujo Jr, 2008). Strong social networks between these areas have facilitated ease and cost of movement, important factors in the decision to migrate (UNDP, 2009). A rural exodus of approximately 50 million people occurred between the 1950s and the 1980s, largely from the leprosy endemic Northeastern region. Until the 1970s, rural-urban migration was the

result of urban industrialization. Secondarily, rural-rural migration was due to the modernization of agriculture and national policies for frontier expansion in the Amazon region. In the 1980s, severe drought in the Northeast affecting rural agriculture, coupled with severe economic decline throughout the country, influenced out-migration from the region. These decades saw the rapid expansion of urban slums and the expansion of settlements in the Amazon through migration, which has been hypothesized as a possible association with the increased distribution of leprosy in these areas (Penna & Oliveira, 2009; Kerr-Pontes, et al., 2004). In urban Rio de Janeiro, a primary destination site for migrants from the Northeast region, leprosy new case detection doubled in the1980s (Andrade, 1996).

The 1990s observed more localized regional migration (Hudson, 1997). While the majority of movement remains between urban centers (Golgher, et al., 2008) , more recently, there has been a shift toward rural in-migration (Golgher, et al., 2008), which can be the result of return, or circular migration to these areas.

As the Brazilian Ministry of Health (MoH) directs its efforts toward leprosy control in areas of high endemic leprosy transmission, interventions targeting high risk and vulnerable groups are an important strategy. Additional protocols should be developed which monitor the effect of population mobility on disease incidence (Watts, 2008; Aagaard-Hansen, Nombela, & Alvar, 2010) and structure services to meet the needs and behavior of migrants. This development would be important as health systems often are not structured to accommodate migrating populations (Deshingkar, 2008; Aagaard-Hansen, Nombela, & Alvar, 2010).

The goal of the study reported in this paper was to support the Brazilian MoH, Leprosy Control program in identifying unique factors associated with migration among those with leprosy in an effort to better target services to migrating populations. The study was designed as an exploratory study to investigate factors associated with migration among those newly diagnosed with leprosy in four endemic areas in the Northeast of Brazil, and separately, factors associated with migration among a clinically unapparent population for comparison. More than one-third of the collective population in the research sites in this study were in-migrants, born in areas outside of the municipality and 7% from outside of state of Maranhão (IBGE, 2010). The objectives were to identify demographic, socioeconomic, clinical, and psychosocial factors uniquely associated with migration among those with leprosy, as migration has been identified as a social determinant of health outcomes.

4.3 Materials and Methods

4.3.1 Study Area

Maranhão state has the third highest annual leprosy case detection rate in Brazil (5.34/10,000 inhabitants in 2010) (MoH, Brazil, 2010). The state ranks sixth on the list of out-migration among states, and had a circular migration rate of 16.4% between 2004 and 2009 (IBGE, 2009). For this study, four highly endemic municipalities in_Maranhão were selected: Santa Inês, São José de Ribamar, Codó, and Bacabal (Figure 4.1).

Figure 4.1: Map of Maranhão and four study sites (Santa Inês, São José de Ribamar, Codó, and Bacabal)

Each of these municipalities is located in a major endemic cluster identified by the Brazilian Ministry of Health as high risk areas for leprosy transmission. Highly endemic clusters were based on national data from 2007 that identified a mean case detection rate of 7.6 per 10,000 residents among 11% of the population (Penna & Penna, 2009), well above the WHO elimination goal of <1 per 10,000.

In 2009-2010, Bacabal had an average population size of 99,251 with a leprosy new case incidence of 12.85 per 10,000 inhabitants; Codó, 115,988 inhabitants with new case incidence of 9.40 per 10,000; São José de Ribamar 151,260 inhabitants and new case incidence of 6.21 per 10,000; and Santa Inês with 81,490 inhabitants and new case incidence of 10.92 per 10,000 (IBGE, 2010). Nearly half of the populations of São José de Ribamar (44.3%) and Santa Inês (45.6%), 29.8% in Bacabal and 17.9% in

Codó were born in other municipalities in Maranhão. Those born outside of the state accounted for 11.2% of the population in Santa Inês, 9% of the population in Bacabal, 8.9% of the population in Codó, and 4.9% in São José de Ribamar (IBGE, 2010).

4.3.2 Study Design

This exploratory population based cross-sectional study was designed to identify factors uniquely associated with migration among those with leprosy compared to non-migrant residents, and included a separate analysis among individuals in a clinically unapparent population without symptoms of leprosy compared to non-migrant residents. A comparison of factors associated with migration among those with leprosy to the clinically unapparent population was explored. Three dependent measures for migration were defined for both those with leprosy and separately for the clinically unapparent population: 1) migration after birth (municipality of birth different from current municipality of residence); 2) past five year migration (migrated from a municipality different from the current residence in the last five years); and 3) past five year circular migration (past five year migrants who were currently living in municipality of birth, but migrated to another municipality in the last five years for a month or more). Migration included all population movement between municipalities, including rural-rural, rural-urban and urban-urban movement. Figure 2 highlights the study design which includes bivariate and multivariate analyses conducted separately for birth, past five year and circular migrants with leprosy compared to non-migrant residents and similarly for migrants in the clinically unapparent population compared to residents. A detailed analysis of the comparison between migrants with leprosy and clinically unapparent migrants that was collected as part of the larger epidemiological study was beyond the scope of factors associated with migration among those with leprosy and will be explored elsewhere.

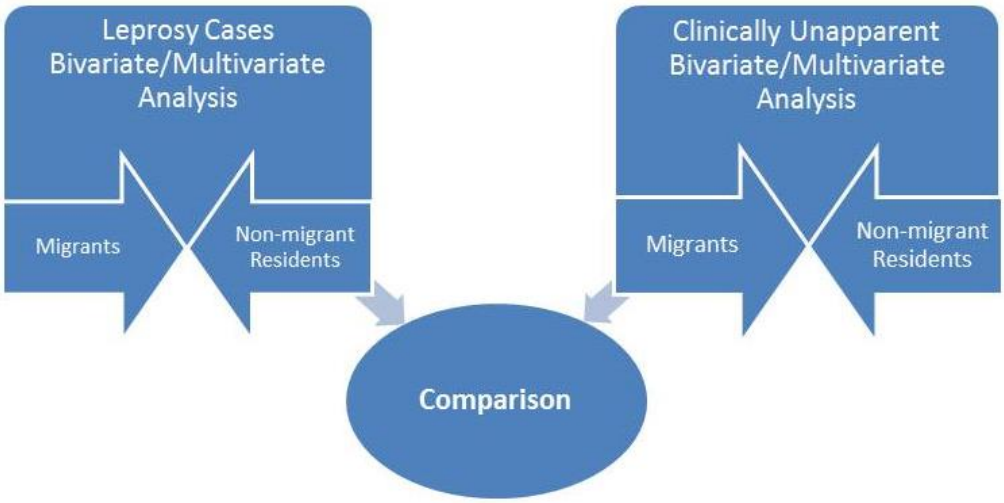


Figure 4.2: Study Design

4.3.3 Data Collection

Data collection was conducted between April and July 2010 as part of a comprehensive epidemiological study conducted by the MAPATOPI project, an interdisciplinary project to support and improve the Brazilian leprosy control program in a major endemic cluster in the states of Maranhão, Tocantins, Piauí and Pará, located in the North and Northeast regions of Brazil.

The leprosy population was identified through the database of the National Information System for Notifiable Diseases (Sistema de *Informação* de Agravos de *Notificação* – SINAN) available from the Brazilian Ministry of Health, and included new leprosy cases diagnosed in 2009-2010, aged >15 years, and living in the four highly endemic municipalities. A clinically unapparent population without symptoms of leprosy, matched to leprosy cases by age, sex and geographic location, was selected from the Programa *Saúde* da *Família* (Program for Family Health), and evaluated for leprosy through an extensive clinical exam. Both leprosy cases and those in the clinically unapparent population with a prior history of leprosy or leprosy relapse, living outside of the endemic municipalities and those who could not be located through multiple contact attempts were excluded.

4.3.4 Field Procedures and Survey Instruments

The Municipality Health Secretariats were informed by the Maranhão State Health Secretariat about the study, and field visits were coordinated for data collection. Patients were invited through community health agents to participate and to be interviewed at the local health care centers.

Home visits, often accompanied by local community health agents, were performed when individuals did not present at the health care center, or had difficulty attending due to age or disability.

A structured questionnaire was used and composed of seven sections: 1) socio-demographics (sex, age, marital status, education, and employment), 2) housing/economic variables (household density, household income, area of residence, and utility access, 3) clinical/disease-related (clinical form of the disease, operational classification, and grade of disability at diagnosis, 4) health services (visits by community health worker, access to health services), 5) migration (history of migration and length of time at residence), 6) behavior (experienced hunger, alcohol consumption, type and frequency), and 7) stress (from disease, job/salary loss, divorce/separation, separation from family/friends, and death of close family/friend). Clinical data was also collected from patients' charts. As data from patients' charts was provided through the local healthcare center, in some cases complete data was unavailable.

4.3.5 Data Analysis

Data were entered twice, using Epi Info software version 3.5.1 (Centers for Disease Control and Prevention, Atlanta, USA) and cross-checked for entry-related errors. Statistical tests were used to assess normality. Data analysis was conducted using STATA version 11 (Stata Corporation, College Station, USA). As a first step, a series of bivariate analyses were conducted examining the significant differences in key theoretical variables for: i) migrants with leprosy after birth compared to non-migrant residents with leprosy, ii) migrants after birth in a clinically unapparent population compared to non-migrant residents in a clinically unapparent population, iii) past 5-year migrants with leprosy compared to non-migrant residents with leprosy, iv) past 5-year migrants in a clinically unapparent population compared to non-migrant residents in a clinically unapparent population, v) past 5-year circular migrants with leprosy compared to non-migrant residents with leprosy, and vi) past 5-year circular migrants in a clinically unapparent population compared to non-migrant residents in a clinically unapparent population. Significant differences ($p<.05$) in the hypothesized variables in these analyses were determined with Fisher's exact tests. Odds ratios and 95% confidence intervals were also computed. In the second step, a series of multivariate analyses were executed. The hypothesized variables found to be significant for each migrant group were included in separate multiple logistic regression models for each migrant group controlling for age, sex and geographic location. A backwards stepwise approach was used to construct these models.

4.3.6 Ethics

The study was approved by the Ethical Review Board of the Federal University of Ceará (Fortaleza, Brazil). Permission to perform the study was also obtained by the Maranhão State Health Secretariat, the State Leprosy Control Program and municipalities involved. Informed written consent was obtained from study participants after explaining the objectives of the study, and interviews were conducted in private.

4.4 Results

4.4.1 Study population characteristics

This study included 394 individuals newly diagnosed with leprosy, and 391 individuals from a clinically unapparent population. A total of 135 individuals were not interviewed because they were either not located at their documented place of residence (n=41), had moved (n=34), or had been transferred to a healthcare facility in another municipality after diagnosis (n=18). Another 18 were traveling/away/working, 2 were incarcerated, and 6 were excluded due to mental disability. Others were ill or hospitalized (n=3), or the place of residence was not reachable/outside of municipality (n=4). Only 8 individuals refused to participate.

Of the 394 individuals with leprosy, 215 (54.6%) were males and 179 (45.4%) were females, ranging in age from 15 to 86 years (mean = 42.9 years; standard deviation = 18.8). In the clinically unapparent population (n=391), 216 (55.2%) were males and 175 (44.8%) were females, aged 15 to 89 years (mean=42.6; standard deviation=18.8). More than one third of the individuals with leprosy were working (n=140; 35.5%), and 254 (64.5%) were unemployed, while 159 (40.7%) in the clinically unapparent population were working and 232 (59.3%) unemployed. Nearly half (n=218, 44.7%) of those with leprosy were illiterate, as compared to 137 (35.0%) from the clinically unapparent population. The mean monthly household income was R$924 among those with leprosy and R$906 in the clinically unapparent population. More than one in four among those with leprosy (n=169, 44.4%) and 159 (42.9%) in the clinically unapparent population were living on less than one minimum wage per month (R$551≈USD $296).

Leprosy-affected individuals included 228 (63.8%) who were classified with multibacillary leprosy. The majority did not have disability at diagnosis (Grade 0) (n=146, 58.2%), which was followed by Grade I (n=82, 32.7%) and Grade II (n=23, 9.2%) disabilities. The clinical form of leprosy was

primarily borderline (n=166, 46.9%), followed by tuberculoid (n=82, 23.2%), lepromatous (n=47, 13.3%), indeterminate (n=44, 12.4%) and neural leprosy (n=15, 4.2%).

Of those with leprosy, 258 (65.5%) were birth migrants, 105 (26.6%) were migrants in the past five years, and 43 (10.9%) were circular migrants. The clinically unapparent population included 266 (68.0%) birth migrants, 81 (20.7%) past five year migrants, and 32 (8.2%) circular migrants.

Variables from the bivariate analysis associated with migration ($p<0.05$) (Appendix 1) were included in the multivariate models.

Among birth migrants with leprosy, demographic, behavioral and clinical factors were found to be associated with migration (Table 1) compared to non-migrant residents with leprosy (not shown). Behavioral variables included life stressors and alcohol consumption among those with leprosy. Stress as a result of separation from family and friends was associated with migration as was drinking alcohol currently. Not being formally employed by being either employed monthly, daily, or self-employed was significantly associated with migration among those with leprosy as was borderline leprosy diagnosis. Stress from separation from family and friends, never worked, and migration among those 45 and older were found to be associated with migrants in the clinically unapparent population (Table 2) compared to clinically unapparent non-migrant residents (not shown).

4.4.2 Factors associated with migration in the past five years

Similar to birth migrants, behavioral and lifestyle stressor variables were also associated with migration among those with leprosy (Table 3) compared to non-migrant residents with leprosy (not shown). Separation from family and friends was significantly associated with migration, as was current alcohol consumption. Two other key factors emerged that differentiated past five year migrants with leprosy from both birth migrants and migrants in the clinically unapparent population: short length of residence in the current household and difficulty in reaching the healthcare center. Among those in the clinically unapparent population (Table 4), separation from family and friends remained significantly associated with migration when compared to clinically unapparent non-migrant residents (not shown). Ages 45 and older were no longer associated with past five year migration in this group. Rather, ages 30 and older were found to be a deterrent to recent migration. Income less than minimum wage (R$511) was also associated with migration in the clinically unapparent population, although no public waste collection, which is sometimes used as a proxy for poverty, was protective.

4.4.3 Factors associated with circular migration five years before diagnosis

Stressors and behavior were associated with circular migration among those with leprosy (Table 5) compared to non-migrant residents with leprosy (not shown), consistent with findings among both past five year and birth migrants. Stress from separation from family and friends was associated with migration among both circular migrants with leprosy compared to non-migrant residents with leprosy, as well as clinically unapparent migrants (Table 6) compared to clinically unapparent non-migrant residents (not shown). Unique to migrants with leprosy, current alcohol consumption as well as difficulty in reaching the healthcare center was associated with circular migration. Age 45-59 was a significant deterrent to migration among those with leprosy, while age 60 and older was only marginally protective.

4.5 Discussion

The role of social inequalities is in the forefront of Neglected Tropical Diseases (NTDs), underscoring the deep divide that places the most marginalized at highest risk for infection (Manderson, et al., 2009; Kerr-Pontes L. , et al., 2004). Among environmental, socioeconomic and cultural risks, migration is suggested to be a determinant for NTDs (Aagaard-Hansen & Chaignat, 2010). Migration interacts with these factors when fundamental social inequalities determine the necessity *to* migrate and conditions *of* migration. This can place migrants at heightened risk for disease while extending disease distribution into new areas.

In this study we assessed factors associated with migration among those with leprosy in Northeast Brazil. We found several distinct behavioral and psychosocial factors - life stressors, alcohol consumption and healthcare access - uniquely associated with migration among individuals with leprosy. Alcohol consumption and healthcare access were not associated with migration in a clinically unapparent population, while life stressors were associated with migrant lifestyle regardless of disease.

We examined socioeconomic status, key demographics and household environment, as these features have been associated with NTD risk (Aagaard-Hansen & Chaignat, 2010; Aagaard-Hansen, Nombela, & Alvar, 2010) and migration (UNDP, 2009; Deshingkar, 2008). However, the majority of these social factors were not found to be associated with migration in Maranhão in this exploratory study. This suggests a high level of social homogeneity between non-migrant residents and migrants residing in the interior and leprosy endemic areas of the state, and also may indicate that social features which are prominent in migrating populations are less pronounced when looking at a vulnerable population, such as those affected by leprosy. Household and family exposure to leprosy,

the primary exposure risk for leprosy infection, was also not found to be significant when comparing migrants with non-migrant residents with leprosy. However, future research should consider the role of family and other leprosy contact exposure during migration.

Separation from family and friends, considered a prominent life stressor (Luhmann, Hofmann, Eid, & Lucas, 2011), was found to be significantly associated with migration. Stress can impact psychological well-being and trigger changes to the biological system of the human body, and has also been found to be associated with compromised immune response and activation of latent infection for infectious disease (Cohen & Williamson, 1991; Vivoli, Rovesti, Borella, & Cermelli, 2008). For migrants, stress may render one more vulnerable to infectious diseases such as leprosy, and influence symptom onset for those previously exposed.

While stress from separation from family and friends was prominent among migrants regardless of leprosy infection, the odds of this stressor among birth and circular migrants were higher than those of migrants in the clinically unapparent population. Lack of social support that would be more readily available in the home environment can negatively influence the psychological adjustment process among those who migrate (Lu, 2010; Bhugra, 2004), and has also been found to increase susceptibility to anxiety and depression among migrants (Lu, 2010). The collective construction of family in Brazil through extended family and intergenerational participation (Dessen & Torres, 2002), takes a significant role in Brazilian culture, and in our study, the majority of migrants lived with family members during the past five year migration period. Poverty, however, has led to increased family separation and inter-regional migration in Brazil (Kaloustian, 1994), most likely separation from the nuclear family due to cost of migration while maintaining extended familial social networks for employment. Irregular non-contractual employment, as was found among birth migrants, often necessitates separation from family when the cost of migration, particularly to urban areas, cannot accommodate nuclear family movement. Day labour was less likely among those aged 60 and older, and self and monthly employment more likely among those aged 45-59.

Social stressors can also lead to other behavioral risk such as alcohol abuse (Keyes, Hatzenbuehler, & Hasin, 2011), and in this study we found that current alcohol consumption differentiates migrants with leprosy from clinically unapparent population. Migration-associated alcohol consumption has been well documented (Borges, et al., 2011; Gupta, Vaidehi, & Majumder, 2010; Garcia, 2008), and has also been found to be associated with mycobacterial disease (de Mattos, Ribeiro, Netto, & d'Azevedo, 2006) and increased susceptibility to infection (Li, et al., 1998), which may be relevant in terms of susceptibility to leprosy infection. In Maranhão, current alcohol consumption was found to

be a significant factor for those newly diagnosed with leprosy who are birth, past five year and circular migrants, compared to non-migrant residents with leprosy. This is particularly concerning among those newly diagnosed with leprosy in terms of interaction with treatment protocols, as alcohol has been found to be a major predictor of leprosy relapse (Ferreira, Ignotti, & Gamba, 2011), which may stem from the effects of alcohol on the absorption of antibiotics (Weathermon & Crabb, 1999). In addition, liver function among those with more severe lepromatous leprosy is compromised and alcohol consumption should be considered in terms of risk for relapse, susceptibility and disease onset. Younger males in Maranhão were the most likely to drink alcohol, which is consistent with other research among migrants (Garcia, 2008).

Social isolation can accompany those who migrate, particularly in countries such as Brazil where the culture validates the role of family relationships in daily life. Alcohol used as a coping mechanism can be expressed as regular alcohol consumption (Gupta, et al., 2010), but also substance abuse (Borges, et al., 2011), and binge drinking (Garcia, 2008). The odds of current alcohol use were fourteen times higher for birth migrants, twice as high for past five year migrants and four times higher for circular migrants with leprosy compared to non-migrant residents with leprosy. Contrarily, alcohol consumption did not differentiate migrants from non-migrant residents in the clinically unapparent population.

In Maranhão, past five year and circular migrants with leprosy had a significantly higher chance of having difficulty reaching the healthcare center than non-migrant residents with leprosy, while there was no significant difference among migrants and non-migrant residents in the clinically unapparent population. In fact, healthcare infrastructure is often not compatible to the needs of migrating populations (Deshingkar, 2008; Aagaard-Hansen, Nombela, & Alvar, 2010). Long hours of employment and unfamiliarity with new living environments are elements that can affect migrant health access, even when symptoms are evident and persistent. Many municipalities in Brazil have adapted their service availability to some extent, with primary healthcare centers now providing hours that accommodate the working population.

Distance and illness were the primary reasons for having difficulty in accessing the health clinics among those with leprosy in our study, and other research has also found that migration was a barrier to health facility utilization (Lu, 2010). Short length of residence among past five year migrants may partially explain difficulty in reaching the healthcare center, as this could be an additional barrier to access for those who are unfamiliar with the region or lack local social support to locate local services. On a positive note, results are from those currently receiving treatment

through their local health center, and another study found that migration is not a barrier to treatment interruption in Brazil after diagnosis (Chichava, et al., 2011). It is nonetheless relevant to point out that illness and distance are significantly higher for migrants than for non-migrant residents with leprosy, and failing to reach migrating populations may hinder control efforts (Sheik-Mohamed & Velema, 1999).

The three main factors – lifestyle stress, alcohol consumption and healthcare access - present important considerations in the role of risks associated with migration and consequently disease control. In their advanced expression, alcohol abuse and significant psychological distress not only affect immune system response, but additionally can also contribute to delay in accessing health services, late diagnosis, and treatment interruption (Lu, 2010; Storla, Yimer, & Bjune, 2008). Thus, it continues to be important to identify mechanisms and adaptations for leprosy control efforts to respond to unique risks associated with migration.

There are some indications that advanced age of 45 or older is a deterrent to migration among both those with leprosy and the clinically unapparent population. A positive association with migration and advanced age among birth migrants in the clinically unapparent population is likely reflective of historic population movement in the 1980s in Brazil, as this is no longer significant in recent past five year and circular migration.

4.6 Limitations

We believe that our study highlights and is representative of national issues surrounding leprosy and migration in Brazil as: 1. the population sample stemmed from endemic municipalities inside of clusters at high-risk for transmission, and 2. the state of Maranhão is among the top states in Brazil with significant in- and out- migration. However, the study presented is a cross-sectional study limited to four municipalities in a hyperendemic area and thus subject to limitations. For example, out-migrants from the study sites were not included in this study, and only data for migrants which are currently present in these sites compared to non-migrant residents was included. Socioeconomic data only concerned the point in time when the research was conducted and thus excludes the timeframe when migration occurred. Data may not reflect the time of actual leprosy infection given a five year average latency period. Data on stress factors pertained to the past five years and could include stress during the post-infection time period.

Due to difficulties in establishing the sequence of events, interpretation of causal relationship should be taken with care. Events may be caused or compounded by migration and/or cause migration

itself. Important indirect factors relevant to leprosy transmission need to be also considered in future research on migration and leprosy in highly endemic municipalities.

4.7 Conclusions

This is the first systematic cross-sectional study focusing on migration among people affected by leprosy. Psychosocial factors and healthcare access emerged as factors significantly associated with migration in this vulnerable population, in contrast to a clinically unapparent population. Findings point to the opportunity to assist migrants in maintaining ties to their home communities, thus not only potentially reducing stressors with separation from family and friends, but also potentially influencing the role of this separation as it may affect alcohol consumption. We included a discussion of both alcohol consumption and stressors as they pertain to reduced immune function and psychological well-being cited in the literature to support our findings, however limited research still exists on the role of alcohol consumption and NTDs susceptibility. Further qualitative and quantitative longitudinal research addressing mild, moderate and severe alcohol consumption could establish causal relationships, and also explore the role of stress and substance use as risks for leprosy infection. Additionally, the role of acute stress through long-term migration and repetitive stress through circular migration could be explored.

As healthcare access emerged as a primary concern for migrants with leprosy, the health sector may consider restructuring services to meet the needs of migrating populations. Extended hours of operation, such as evening and weekend hours would be an important first step in this regard. Additionally, assistance with transportation to clinical facilities or providing mobile medical care could potentially alleviate problems associated with access. Facilitating the ease of healthcare access may increase early diagnosis and thus reduce advanced disability and improve medication adherence, while also supporting leprosy elimination and control in Brazil.

4.8 Acknowledgements

We thank the entire team of the Leprosy Control Program and the State Health Secretariat of Maranhão. Collaboration of the Municipalities' Health Secretariats and Primary Health Care Centers is acknowledged. We are also grateful to all patients that kindly agreed to participate in the study. Special thanks to Professor Marcel Tanner of the Swiss Tropical and Public Health Institute (SwissTPH) his insightful comments on the manuscript, and Dr. Penelope Vounatsou (SwissTPH) for guidance on the statistical analysis.

The research project "MAPATOPI" was financed by the *Conselho Nacional de Desenvolvimento Científico e Tecnológico* (CNPq) and the Department of Science and Technology of the Brazilian Ministry of Health (DECIT), Brazil. JH is research fellow from CNPq, CHA was provided a scholarship through *Fundação Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* (CAPES, Brazil) .

Table 4.1: Multivariate analysis of factors associated with migration after birth among migrants diagnosed with leprosy compared to non-migrant residents with leprosy

	Migration after birth Leprosy Cases Migrants† n=258 (66.2%)	AOR (95% CI)*	P
Worker contract status (Employed)			
Formally employed	18 (45.0%)	1.0	
Self-employed	13 (68.4%)	15.27 (1.44 –161.69)	**0.02**
Monthly employment	14 (73.7%)	8.83 (1.53 – 50.81)	**0.02**
Day labour	43 (74.1%)	10.35 (2.59 – 41.31)	**0.001**
Alcohol consumption			
Never drank	54 (53.5%)	1.0	
Drink currently	38 (67.9%)	14.53 (1.64 – 128.31)	**0.02**
Drank in past 5 yrs	120 (68.6%)	5.65 (0.95 – 33.45)	0.56
Stopped drinking > 5 years ago	41 (80.4%)	6.69 (0.65 – 69.15)	0.11
Difficulty to reach the healthcare center			
Yes	73 (76.8%)	0.91 (0.20 – 4.17)	0.91
No	184 (62.8%)	1.0	
Stress –Separated from family/friends			
Yes	57 (78.1%)	7.64 (1.25 – 46.71)	**0.03**
No	200 (63.3%)	1.0	
Stress Job/Salary Loss			
Yes	77 (77.0%)	0.92 (0.25 – 3.48)	0.91
No	180 (62.3%)	1.0	
Leprosy Diagnosis			
Tuberculoid	48 (59.3%)	4.36 (0.79 – 24.11)	0.09
Borderline	123 (75.5%)	5.41 (1.01 – 29.14)	**0.049**
Lepromatous	27 (57.5%)	0.15 (0.02 – 1.33)	0.09
Indeterminate	22 (50.0%)	1.0	
Neural	9 (60.0%)	0.84 (0.03 – 21.87)	0.92

† Data not available for all individuals, significant at 95% ($p<0.05$) are highlighted in bold,
*adjusted odds rates (AOR) are only presented for those variables included in the final regression model

Table 4.2: Multivariate analysis of factors associated with migration after birth among migrants in a clinically unapparent population without symptoms of leprosy compared to clinically unapparent non-migrant residents

	Migration after birth Clinically Unapparent Population Migrants† n=266 (68.4%)	AOR (95% CI)*	P
Age-groups (yrs)			
15-29	71 (55.0%)	1.0	
30-44	54 (64.3%)	1.20 (0.65 – 2.2)	0.56
45-59	67 (77.9%)	2.4 (1.15 – 5.01)	**0.02**
≥60	74 (82.2%)	3.08 (1.3 – 7.31)	**0.01**
Sex			
Male	157 (72.7%)	1.27 (0.79 – 2.03)	0.32
Female	109 (63.0%)	1.0	
Education			
No formal education	107 (78.7%)	1.20 (0.62 – 2.34)	0.59
Some education	159 (62.9%)	1.0	
Life Occupation			
Farmer	105 (76.6%)	0.80 (0.43 – 1.49)	0.48
Never worked	20 (40.0%)	0.39 (0.2 – 0.78)	**0.01**
Other work	139 (69.5%)	1.0	
Stress Separated from family/friends	55 (78.6%)	2.35 (1.22 – 4.51)	
Yes	55 (78.6%)	2.35 (1.22 – 4.51)	**0.01**
No	211 (66.1%)	1.0	

† Data not available for all individuals, significant at 95% ($p<0.05$) are highlighted in bold,
*adjusted odds rates (AOR) are only presented for those variables included in the final regression model

Table 4.3: Multivariate analysis of factors associated with past 5 year migration among migrants diagnosed with leprosy compared to non-migrant residents with leprosy

	Past 5 year Migration Leprosy Cases Migrants† n=105 (26.7)	AOR (95% CI)*	P
Age-groups (yrs)			
15-29	43 (33.6%)	1.0	
30-44	29 (33.7%)	0.75 (0.35 – 1.58)	0.45
45-59	19 (21.8%)	0.57 (0.24 – 1.3)	0.28
≥60	14 (15.2%)	0.45 (0.16 – 1.31)	0.14
Education			
No formal education	34 (19.4%)	0.66 (0.29 – 1.49)	0.32
Some education	71 (32.6%)	1.0	
Head of Household Education			
No formal education	42 (20.4%)	0.90 (0.43 – 1.85)	0.77
Some education	54 (32.5%)	1.0	
Life Occupation			
Farmer	31 (21.2%)	0.83 (0.41 – 1.68)	0.60
Never worked	12 (23.5%)	0.77 (0.29 – 2.02)	0.59
Other work	62 (31.0%)	1.0	
Electricity			
No	4 (80.0%)	14.75 (1.09 – 199.83)	0.43
Yes	101 (26.0%)	1.0	
Length of time in current residence			
0 – 4 years	61 (43.0%)	2.51 (1.37 – 4.63)	**0.003**
5 –10 years	12 (17.4%)	0.74 (0.31 – 1.77)	0.50
≥ 11 years	30 (17.7%)	1.0	
Alcohol consumption			
Never drank	18 (17.7%)	1.0	
Drink currently	19 (33.9%)	2.52 (1.01 – 6.28)	**0.047**
Drank in past 5 yrs	56 (31.8%)	1.88 (0.87 – 4.07)	0.12
Stopped drinking > 5 yrs ago	10 (19.6%)	1.40 (0.48 – 4.11)	0.54
Difficulty to reach the healthcare centre			
Yes	36 (37.9%)	2.23 (1.22 – 4.09)	**0.01**
No	69 (23.3%)	1.0	
Stress Job/Salary Loss			
Yes	38 (37.3%)	1.54 (0.81 – 2.94)	0.19
No	67 (23.1%)	1.0	
Stress Divorce/Separated			
Yes	26 (37.7%)	0.76 (0.35 – 1.63)	0.48
No	79 (24.5%)	1.0	
Stress Separated from family/friends			
Yes	34 (46.0%)	2.64 (1.36 – 5.10)	**0.004**
No	71 (22.3%)	1.0	

† Data not available for all individuals, significant at 95% ($p<0.05$) are highlighted in bold,

*adjusted odds rates (AOR) are only presented for those variables included in the final regression model

Table 4.4: Multivariate analysis of factors associated with past 5 year migration among migrants in a clinically unapparent population without symptoms of leprosy compared to clinically unapparent non-migrant residents

	Past 5 year Migration Clinically Unapparent Population		
	Migrants† n=81 (20.7)	**AOR (95% CI)***	P
Age-groups (yrs)			
15-29	41 (31.3%)	1.0	
30-44	22 (26.2%)	0.72 (0.34 – 1.55)	**0.02**
45-59	11 (12.8%)	0.3 (0.11 – 0.84)	**0.02**
≥60	7 (7.8%)	0.23 (0.07 – 0.78)	**0.01**
Education			
No formal education	15 (11.0%)	1.04 (0.35 – 3.1)	0.9
Some education	66 (26.0%)	1.0	
Head of Household Education			
No formal education	22 (12.5%)	0.61 (0.27 – 1.4)	0.25
Some education	53 (26.2%)	1.0	
Life Occupation			
Farmer	18 (13.1%)	1.57 (0.66 – 3.72)	0.3
Never worked	13 (26.0%)	0.94 (0.38 – 2.32)	0.89
Other work	49 (24.3%)	1.0	
Home ownership			
No	10 (55.6%)	3.34 (0.99 – 11.25)	0.05
Yes	71 (19.1%)	1.0	
Household monthly income††			
>511 R$	54 (25.5%)	1.0	
0 – 511.R$	26 (16.4%)	2.15 (1.09 – 4.23)	**0.02**
Public waste collection			
No	11 (11.9%)	0.43 (0.19 – 0.97)	**0.03**
Yes	70 (23.7%)	1.0	
Stress Separated from family/friends			
Yes	34 (48.6%)	5.76 (2.96 – 11.22)	**<0.0001**
No	47 (14.6%)	1.0	

† Data not available for all individuals, † † At the time of the survey 1US$ was equivalent to 1.72R$, and R$ 511,- the official minimum wage as set by the Federal Government , significant at 95% (p<0.05) are highlighted in bold,

*adjusted odds rates (AOR) are only presented for those variables included in the final regression model

Table 4.5: Multivariate analysis of factors associated with past 5 year circular migration among migrants diagnosed with leprosy compared to non-migrant residents with leprosy

	Past 5 year Circular Migration		
	Leprosy Cases		
	Migrants†		
	n=43 (24.57)	AOR (95% CI)*	P
Age-groups (years)			
15-29	25 (32.1%)	1.0	
30-44	13 (31.7%)	0.82 (0.29 – 2.29)	0.7
45-59	3 (10.0%)	0.17 (0.04 – 0.79)	**0.02**
≥60	2 (7.7%)	0.1 (0.01 – 1.12)	0.06
Education			
No formal education	10 (15.9%)	0.84 (0.25 – 2.8)	0.77
Some education	33 (29.5%)	1.0	
Head of Household Education			
No formal education	15 (17.1%)	0.57 (0.22 – 1.49)	0.26
Some education	25 (32.5%)	1.0	
Alcohol consumption			
Never drank	6 (11.3%)	1.0	
Drink currently	12 (40.0%)	4.46 (1.3 – 15.34)	**0.02**
Drank in past 5 years	22 (28.6%)	2.26 (0.7 – 7.29)	0.17
Stopped drinking > 5 years ago	2 (16.7%)	2.47 (0.27 – 22.92)	0.43
Difficulty to reach the healthcare centre			
Yes	16 (42.1%)	2.72 (1.07 – 6.93)	**0.04**
No	27 (19.9%)	1.0	
Time to Diagnosis			
<7 days	25 (25.3%)	1.0	
7-30 days	11 (29.0%)	1.14 (0.41 – 3.17)	0.8
30-60 days	1 (20.0%)	1.39 (0.1 – 19.1)	0.81
>60 days	6 (20.7%)	1.18 (0.33 – 4.2)	0.8
Stress –Separated from family/friends			
Yes	14 (46.7%)	4.71 (1.66 – 13.41)	**0.004**
No	29 (20.0%)	1.0	

† Data not available for all individuals, significant at 95% ($p<0.05$) are highlighted in bold,
*adjusted odds rates (AOR) are only presented for those variables included in the final regression model

Table 4.6: Multivariate analysis of factors associated with past 5 year circular migration among migrants in a clinically unapparent population without symptoms of leprosy compared to clinically unapparent non-migrant residents

	Past 5 year Circular Migration Clinically Unapparent Population Migrants† n=32 (20.65)	AOR (95% CI)*	P
Life Occupation			
Farmer	7 (18.0%)	0.55 (0.21 – 1.5)	0.23
Never worked	3 (9.1%)	0.27 (0.08 – 1.03)	0.06
Other work	22 (26.5%)	1.0	
Stress Separated from family/friends			
Yes	10 (40.0%)	3.36 (1.3 – 8.66)	**0.01**
No	22 (16.9%)	1.0	

† Data not available for all individuals, significant at 95% ($p<0.05$) are highlighted in bold,
*adjusted odds rates (AOR) are only presented for those variables included in the final regression model

4.9 References

Aagaard-Hansen, J., & Chaignat, C. (2010). Neglected tropical diseases: equity and social determinants. In WHO, E. Blas, & A. S. Kurup (Eds.). Geneva: WHO.

Aagaard-Hansen, J., Nombela, N., & Alvar, J. (2010). Population movement: a key factor in the epidemiology of neglected tropical diseases. *Trop Med Intl Health*, 1281-1288.

Ackah, C., & Medvedev, D. (2010). *Internal migration in Ghana: Determinants and welfare impacts.* Washington, D.C.: World Bank/West Africa Poverty Reduction and Economic Management Unit (World Bank Policy Research Working Paper Series, 5273).

Allotey, P., Reidpath, D., & Pokhrel, S. (2010). Social sciences research in neglected tropical diseases: the ongoing neglect in the neglected tropical diseases. *Health Research Policy and Systems, 8:32*.

Andrade, V. (1996). Evolução da Hanseniase no Brasil e Perspectivas Para Sua Eliminação como Um Problema de Saude Publica. RJ, Brazil: Escola Nacional de Saúde Pública da Fundação Oswaldo Cruz.

Bhugra, D. (2004). Migration and mental health. *Acta Psychiatr Scand , 109*, 243-58.

Borges, G., Breslau, J., Orozco, R., Tancredi, D., Anderson, H., Aguilar-Gaxiola, S., & Mora, M.E. (2011). A cross-national study on Mexico-US migration, substance use and substance use disorders. *Drug and Alcohol Dependence, 117*(1), 16-23.

Brazil, MoH. (2010). *Indicadores de morbidade e factores de risco. Taxa de prevalencia de hanseniase.* Retrieved from http://tabnet.datasus.gov.br/cgi/deftohtm.exe?idb2011/d0206.def.

Chichava, O.A., Ariza, L., Oliveira, A.R., Ferreira, A.C., da Silva, L.F., Barbosa, A.N., Ramos, Jr., A.N., & Heukelbach, J., et al. (2011). Reasons for Interrupting Multidrug Therapy Against Leprosy. *Leprosy Review, 82*, 78-9.

Cohen, S., & Williamson, G. (1991). Stress and infectious disease in humans. *Psychological Bulletin, 109*, 5-24.

de Mattos, I., Ribeiro, M., Netto, I., & d'Azevedo, P. (2006). Tuberculosis: a study of 111 cases in an area of high prevalence in the extreme south of Brazil. *Braz J Infect Dis, 10*(3), 194-8.

Deshingkar, P. (2008). Circular Internal Migration and Development in India. In J. DeWind, & J. Holdaway (Eds.), *Migration and Development Within and Across Borders: Reserach and Policy Perspectives on Internal and International Migration* (pp. 161-187). Geneva: IOM and SSRC.

Dessen, M. A., & Torres, C. V. (2002). Family and socialization factors in Brazil: An overview. In W. J. Lonner, D. L. Dinnel, S. A. Hayes, & D. N. Sattler (Eds.), *Online Readings in Psychology and Culture.* Bellingham, Washington: Center for Cross-Cultural Research, Western Washington University, http://www.wwu.edu/~culture.

Ferreira, S. I., Ignotti, E., & Gamba, M. (2011). Factors associated to relapse of leprosy in Mato Grosso, Central-Western Brazil. *Rev. Saúde Pública, 45*(4), 756-64.

Garcia, V. (2008). Problem drinking among transnational Mexican migrants: Exploring migrant status and situational factors. *Human Organization , 67*(1), 12-24.

Golgher, A., Rosa, C., & Araujo Jr, A. (2008). Determinants of migration in Brazil: Regional Polarization and Povety Traps. *Papeles de Poblacion*(56), 135-171.

Gupta, K., Vaidehi, Y., & Majumder, N. (2010). Spatial Mobility, Alcohol Use, Sexual Behavior and Sexual Health Among Males in India. *AIDS and Behavior, 14*(Supplement 1), 18-30.

Hudson, R. (1997). *Brazil: A Country Study.* GPO, Library of Congress, Washington, DC.

Instituto Brasileiro de Geografia e Estatística (IBGE). (2009). PNAD National Household Survey 2004/2009. *Publication approaches theoretical aspects of population mobility and analyzes the migration flows in Brazil*. Retrieved from http://www.ibge.gov.br/english/presidencia/noticias/noticia_visualiza.php?id_noticia=1928&id_pagina=1

Instituto Brasileiro de Geografia e Estatística (IBGE). (2010). *Results of Population Census 2010*. Retrieved from ftp://ftp.ibge.gov.br/Censos/Censo_Demografico_2010/Nupcialidade_Fecundidade_Migracao/tab1_3.pdf.

Kaloustian, S. (1994). *Família Brasileira, a Base De Tudo.* Brasilia: Cortez and UNICEF.

Kerr-Pontes, L.R.S., Montenegro, A.C., Barreto, M.L., Werneck, G.L., & Feldmeier, H. (2004). Inequality and leprosy in Northeast Brazil: an ecological study. *Int J of Epid, 33*, 262-269.

Keyes, K., Hatzenbuehler, M., & Hasin, D. (2011). Stressful life experiences, alcohol consumption, and alcohol use disorders: the epidemiologic evidence for four main types of stressors. *Psychopharmacology, 218*(1), 1-17.

Li, X., Grossman, C.J., Mendenhall, C.L., Hurtubise, P., Rouster, S.D., Roselle, G.A., & Gartside, P. (1998). Host response to mycobacterial infection in the alcoholic rat: male and female dimorphism. *Alcohol, 16*(3), 207-12.

Lindstrom, D., & Lauster, N. (2001). Local Economic Opportunity and the Competing Risks of Internal and US Migration in Zacatecas, Mexico. *Int Mig Rev, 35*(4), 1232-1256.

Lu, Y. (2010). Rural-urban migration and health: Evidence from longitudinal data in Indonesia. *Social Science & Medicine , 70*, 412-19.

Luhmann, M., Hofmann, W., Eid, M., & Lucas, R. E. (2011). *Subjective Well-Being and Adaptation to Life Events: A.* Retrieved from http://psycnet.apa.org/?&fa=main.doiLanding&doi=10.1037/a0025948

Manderson, L., Aagaard-Hansen, J., Allotey, P., Gyapong, M., & Sommerfeld, J. (2009). Social Research on Neglected Diseases of Poverty: Continuing and Emerging Themes. *PLoS Negl Trop Dis, 3*(2), e332.

Murto, C., Ariza, L., Oliveira, A.R., Chichava, O.A., Alencar, C.H., da Silva, LR.M., Tanner, M., & Heukelbach, J., et al. (2012). Motives and determinants for residence change after leprosy diagnosis, central Brazil. *Leprosy Review, 83*(1), 16-23.

Penna, M.L.F., Oliveira, M.L.W., & Penna, G. (2009). Spatial distribution of leprosy in the Amazon region of Brazil. Retrieved from http://wwwnc.cdc.gov/eid/article/15/4/08-1378.htm. *Emerg Infect Dis*. 15(4), 650-652.

Penna, M.L.F., & Penna, G. (2009). The epidemiological behavior of leprosy in Brazil. *80*, 332-44.

Perlman, J. (2007). *Globalization and the Urban Poor.* World Institute for Development Economics Research, World Institute for Development Economics Research. New York: United Nations University.

Rayp, G., Ruyssen, I. (2010) *Africa on the move: an extended gravity model of intra-regional migration.* Paper presented at Migration, A World in Motion: A multinational Conference on Migration and Migration Policy, Association for Public Policy Analysis and Management (APPAM); February 18-20. Maastricht, Netherlands; 2010 . Retrieved from http://umdcipe.org/conferences/Maastricht/conf_papers/Papers/Africa_on_the_Move.pdf .

Sales, A., Leon, A., Duppre, N., Hacker, M., Nery, J., Sarno, E., & Penna, M.L.F. (2011). Leprosy among patient contacts: A multilevel study of risk factors. *PLOS NTD, 5*(3), e1013.

Sheik-Mohamed, A., & Velema, J. P. (1999). Where health care has no access: the nomadic populations of sub-Saharan Africa. *Tropical Medicine and International Health, 4*(10), 695-707.

Storla, D., Yimer, S., & Bjune, G. (2008). A systematic review of delay in the diagnosis and treatment of tuberculosis. *BMC Public Health, 8:15*.

UNDP. (2009). *Overcoming barriers: Human mobility and development.* UNDP. New York: UNDP.

Vivoli, R., Rovesti, S., Borella, P., & Cermelli, C. (2008). Relation between psychoneuroendocrine profile in stressful conditions and antibodies to herpesvirus 6 and 7. *J Biol Regul Homeost Agents, 22*(4), 239-45.

Watts, S. (2008, January 23). *The Social Determinants of Schistosomiasis.* Retrieved from TropIKA.net: http://www.tropika.net/review/051114-Schistosomiasis_Social_Determinants/article.pdf

Weathermon, R., & Crabb, D. (1999). Alcohol and medication interactions. *Alcohol Res Health, 23*(1), 40-54.

WHO. (2002). Urbanization: an increasing risk factor for leishmaniasis. *Weekly Epidemiological Records, 77*, 365-72.

WHO. (2008). *Closing the gap in a generation: health equity through action on the social determinants of health. Final Report.* Commission on Social Determinants of Health (CSDH). Geneva: World Health Organization.

Appendix Chapter 4

Table 4A.1: Bivariate analysis of factors associated with migration after birth among migrants diagnosed with leprosy compared to non-migrant residents with leprosy, and migrants after birth in a clinically unapparent population without symptoms of leprosy compared to clinically unapparent non-migrant residents

	Birth Migration Leprosy cases			Birth migration Clinically Unapparent Population		
	Migrants† n=258 (66.2%)	OR (95% CI)*	p	Migrants† n=266 (68.4%)	OR (95% CI)*	p
Socio-demographic variables						
Sex						
Male	146 (68.2%)	1.23 (0.79 – 1.91)	0.39	157 (72.7%)	1.56 (0.99 - 2.46)	**0.048**
Female	112 (63.6%)	Reference		109 (63.0%)	Reference	
Age-groups (years)						
15-29	74 (58.3%)	0.67 (0.36 – 1.24)	0.2	71 (55.0%)	0.68 (0.37 – 1.24)	0.20
30-44	58 (67.4%)	Reference		54 (64.3%)	Reference	
45-59	59 (68.6%)	1.05 (0.53 – 2.11)	1.0	67 (77.9%)	1.96 (0.95 – 4.1)	0.06
≥60	67 (73.6%%)	1.35 (0.67 – 2.72)	0.41	74 (82.2%)	0.12 (0.06 – 0.25)	**0.0**
Education						
No formal education	120 (69.4%)	1.30 (0.83 – 2.03)	0.24	107 (78.7%)	2.18 (1.32 – 3.67)	**0.001**
Some education	138 (63.6%)	Reference		159 (62.9%)	Reference	
Head of Household Education						
No formal education	133 (64.6%)	0.86 (.53 – 1.34)	0.51	125 (71.0%)	1.26 (0.80 – 2.1)	0.32
Some education	112 (68.3%)	Reference		132 (66.0%)	Reference	
Worker contract status						
Formal employee/public servant	18 (45.0%)	Reference		27 (69.2%)	Reference	
Self-employed	13 (68.4%)	2.65 (0.74 – 10.16)	0.11	10 (83.3%)	2.22 (0.38 – 23. 59)	0.47

Monthly employment	14 (73.7%)	3.42 (0.92 – 14.26)	0.05	16 (61.5%)	0.71 (0.22 – 2.31)	0.60
Day labour	43 (74.1%)	3.5 (1.37 – 9.03)	**0.01**	53 (66.3%)	0.87 (0.35 – 2.12)	0.84
Life Occupation						
Farmer				105 (76.6%)	1.44 (0.85 – 2.45)	0.17
Never worked				20 (40.0%)	0.28 (0.14 – 0.56)	**0.0001**
Other employment		Reference		139 (69.5%)	Reference	
Health service-related variables						
Difficulty perceived to reach the health care center						
Yes	73 (76.8%)	1.97 (1.13 – 3.52)	**0.013**	17 (58.6%)	0.63 (0.28 – 1.51)	0.30
No	184 (62.8%)	Reference		248 (69.1%)	Reference	
Behavioural variables						
Alcohol consumption						
Never drank	54 (53.5%)	Reference		70 (67.3%)	Reference	
Drink currently	38 (67.9%)	1.84 (0.88 – 3.89)	0.09	116 (67.8%)	1.02 (0.57 – 1.78)	1.0
Drank in past 5 years	120 (68.6%)	1.9 (1.11 – 3.24)	**0.01**	32 (66.7%)	0.97 (0.45 – 2.17)	1.0
Stopped drinking more than 5 years ago	41 (80.4%)	3.57 (1.53 – 8.82)	**0.001**	47 (72.3%)	1.27 (0.61 – 2.68)	0.61
Stress Related Variables Past 5 years						
Stress – Job/Salary Loss						
Yes	77 (77.0%)	2.03 (1.17 – 3.59)	**0.007**	71 (74.7%)	1.50 (0.87 – 2.65)	0.13
No	180 (62.3%)	Reference		195 (66.3%)	Reference	
Stress –Separated from family/friends						
Yes	57 (78.1%)	2.07 (1.11 – 4.03)	**0.02**	55 (78.6%)	1.88 (0.99 – 3.74)	**0.047**
No	200 (63.29%)	Reference		211 (66.1%)	Reference	
Leprosy DiseaseVariables						
Tuberculoid	48 (59.3%)	1.45 (0.65 – 3.25)	0.35			

Borderline	123 (75.5%)	3.08 (1.45 – 6.48)	**0.002**
Lepromatous	27 (57.4%)	1.35 (0.55 – 3.35)	0.53
Indeterminate	22 (50.0%)	Reference	
Neural	9 (60.0%)	1.5 (0.39 0 6.03)	0.56

† Data not available for all individuals, significant at 95% ($p<0.05$) are highlighted in bold, *adjusted odds rates (AOR) are only presented for those variables included in the final regression model

Table 4A.2: Bivariate analysis of factors associated with past 5 year migration among migrants diagnosed with leprosy compared to non-migrant residents with leprosy, and past 5 year migrants in a clinically unapparent population without symptoms of leprosy compared to clinically unapparent non-migrant residents

	Past 5 year Migration Leprosy Cases			Past five year migration Clinically Unapparent Population		
	Migrants† n=105 (26.7%)	OR (95% CI)*	p	Migrants† n=81 (20.7%)	OR (95% CI)*	p
Socio-demographic variables						
Age-groups (years)						
15-29	43 (33.6%)	0.99 (0.54 – 1.85)	1.0	41 (31.3%)	1.28 (0.67 – 2.5)	0.45
30-44	29 (33.7%)	Reference		22 (26.2%)	Reference	
45-59	19 (21.8%)	0.55 (0.26 – 1.14)	0.09	11 (12.8%)	0.41 (0.17 – 0.98)	**0.03**
≥60	14 (15.2%)	0.35 (0.16 – 0.77)	**0.049**	7 (7.8%)	0.24 (0.08 – 0.63)	**0.02**
Education						
No formal education	34 (19.4%)	0.5 (0.3 – 0.82)	**0.004**	15 (11.0%)	0.35 (0.18 – 0.66)	**0.0004**
Some formal education	71 (32.6%)	Reference		66 (26.0%)	Reference	
Head of Household Education						
No formal education	42 (20.4%)	0.53 (0.32 - 0.87)	**0.01**	22 (12.5%)	0.40 (0.22 – 0.71)	**0.001**
Some formal education	54 (32.5%)	Reference		53 (26.2%)	Reference	
Life Occupation						
Farmer	31 (21.2%)	0.57 (0.34 – 0.97)	**0.04**	18 (13.1%)	0.47 (0.25 – 0.88)	**0.01**
Never worked	12 (23.5%)	0.66 (0.29 – 1.39)	0.3	13 (26.0%)	1.10 (0.49 – 2.34)	0.86
Other employment	62 (32.0%)	Reference		49 (24.3%)	Reference	

Housing- and economic-related variables						
Household monthly income††						
>511 R$ (≈270.US$)	51 (24.2%)	Reference	0.2	54 (25.5%)	Reference	**0.04**
0 – 511.R$	51 (30.2%)	1.36 (0.84 - – 2.19)		26 (16.6%)	0.57 (0.32 – 0.99)	
Home ownership						
No	14 (41.2%)	2.06 (0.92 – 4.49)	0.07	10 (55.6%)	5.30 (1.80 – 15.96)	**0.001**
Yes	91 (25.4%)	Reference		71 (19.1%)	Reference	
Electricity						
No	4 (80.0%)	11.37 (1.10- 561.56)	**0.02**	1 (50.0%)	3.84 (0.48 – 302.17)	0.37
Yes	101 (26.0%)	Reference		80 (20.7%)	Reference	
Public waste collection						
No	24 (27.3%)	1.03 (0.58 – 1.08)	0.89	11 (11.6%)	0.42 (0.19 – 0.85)	**0.01**
Yes	81 (26.7%)	Reference		70 (23.7%)	Reference	
Length of time lived in current residence						
0 – 4 years	61 (43.0%)	3.61 (2.10 – 6.27)	**<0.0001**	35 (34.0%)	2.59 (1.44 – 4.65)	**0.001**
5 –10 years	12 (17.4%)	1.01 (0.44 – 2.20)	1.0	12 (1.5%)	0.89 (0.39 – 1.89)	0.86
≥ 11 years	30 (17.7%)	Reference		34 (16.6%)	Reference	
Health service-related variables						
Difficulty perceived to reach the health care centre						
Yes	36 (37.9%)	2.01 (1.18 - 3.38)	**0.01**	5 (17.3%)	0.78 (0.23 – 2.19)	0.81
No	69 (23.3%)	Reference		76 (21.1%)	Reference	

Behavioral variables						
Alcohol consumption						
Never drank	18 (17.7%)	Reference		17 (16.4%)	Reference	
Drink currently	19 (33.9%)	2.40 (1.05 – 5.44)	**0.03**	46 (25.7%)	1.85 (0.97 – 3.68)	0.05
Drank in past 5 years	56 (31.8%)	2.18 (1.16 – 4.22)	**0.01**	12 (25.0%)	1.71 (0.67 – 4.23)	0.27
Stopped drinking more than 5 years ago	10 (19.6%)	1.14 (0.43 – 2.88)	0.83	6 (9.2%)	0.52 (0.16 – 1.49)	0.25
Stress Related Variables Past 5 years						
Stress – Job/Salary Loss						
Yes	38 (37.3%)	1.98 (1.18 – 3.29)	**0.007**	25 (26.3%)	1.53 (0.85 – 2.70)	0.15
No	67 (23.1%)	Reference		56 (18.9%)	Reference	
Stress – Divorced/Separated						
Yes	26 (37.7%)	1.87 (1.03 – 3.34)	**0.04**	19 (31.2%)	2.00 (1.00 – 3.71)	**0.04**
No	79 (24.5%)	Reference		62 (18.8%)	Reference	
Stress –Separated from family/friends						
Yes	34 (46.0%)	2.96 (1.68 – 5.17)	**0.0001**	34 (48.6%)	5.51 (3.01 – 10.01)	**<0.0001**
No	71 (22.3%)	Reference		47 (14.6%)	Reference	

† Data not available for all individuals, †† At the time of the survey 1US$ was equivalent to 1.72R$, and R$ 510,- the official minimum wage as set by the Federal Government, significant at 95% ($p<0.05$) are highlighted in bold, *adjusted odds rates (AOR) are only presented for those variables included in the final regression model

Table 4A.3: Bivariate analysis of factors associated with past 5 year circular migration (past five year migrant, municipality of birth same as current municipality of residence) among migrants diagnosed with leprosy compared to non-migrant residents with leprosy, and past 5 year circular migrants in a clinically unapparent population without symptoms of leprosy compared to clinically unapparent non-migrant residents

	Past 5 year Circular Migration Leprosy Cases			Past five year circular migration Clinically Unapparent Population		
	Migrants† n=43 (24.6%)	**OR (95% CI)***	**p**	**Migrants† n=32 (20.7%)**	**OR (95% CI)***	**p**
Socio-demographic variables						
Age-groups (years)						
15-29	25 (32.1%)	1.01 (0.42 – 2.51)	1.0	19 (24.7%)	1.97 (0.62 – 7.37)	0.32
30-44	13 (31.7%)	Reference		5 (14.3%)	Reference	
45-59	3 (10.0%)	0.24 (0.04 – 1.03)	**0.04**	6 (24.0%)	1.89 (0.41 – 8.96)	0.5
≥60	2 (7.7%)	0.18 (0.02 – 0.94)	**0.03**	2 (11.1%)	0.75 (0.06 – 5.27)	1.0
Education						
No formal education	10 (15.9%)	0.45 (0.18 – 1.04)	**0.047**	5 (14.7%)	0.60 (0.17 -1.79)	0.47
Some education	33 (29.5%)	Reference		27 (22.3%)	Reference	
Head of Household Education						
No formal education	15 (17.1%)	0.43 (0.19 – 0.94)	**0.03**	9 (15.0%)	0.60 (0.22 – 1.52)	0.29
Some education	25 (32.5%)	Reference		20 (22.7%)	Reference	
Life Occupation						
Farmer	15 (25.9%)	1.24 (0.52 – 2.92)	0.69	7 (18.0%)	0.61 (0.20 – 1.68)	0.37
Never worked	10 (29.4%)	1.48 (0.53 – 3.96)	0.48	3 (9.1%)	0.28 (0.05 – 1.04)	**0.046**
Other employment	18 (22.0%)	Reference		22 (26.5%)	Reference	
Health service-related variables						

Difficulty perceived to reach the health care centre						
Yes	16 (42.1%)	2.93 (1.25 – 6.75)	**0.01**	1 (7.7%)	0.30 (0.01 – 2.18)	0.31
No	27 (19.9%)	Reference		31 (21.8%)	Reference	
Behavioral variables						
Alcohol consumption						
Never drank	6 (11.3%)	Reference		8 (19.1%)	Reference	
Drink currently	12 (40.0%)	5.22 (1.51 – 19.29)	**0.005**	17 (23.6%)	1.31 (0.47 – 3.91)	0.64
Drank in past 5 years	22 (28.6%)	3.13 (1.10 – 10.17)	**0.03**	5 (23.8%)	1.33 (0.29 – 5.50)	0.75
Stopped drinking more than 5 years ago	2 (16.7%)	1.57 (0.13 – 10.53)	0.63	2 (10.0%)	0.47 (0.05 – 2.76)	0.48
Stress Related Variables Past 5 years						
Stress –Separated from family/friends						
Yes	14 (46.7%)	3.50 (1.40 – 8.61)	**0.004**	10 (40.0%)	3.27 (1.15 – 8.95)	**0.02**
No	29 (20.0%)	Reference		22 (16.9%)	Reference	
Disease Variables						
Time to Diagnosis						
<7 days	25 (25.3%)	Reference				
7-30 days	11 (29.0%)	1.21 (0.47 – 2.96)	0.67			
30-60 days	1 (20.0%)	11.84 (1.08 – 590.6)	**0.02**			
>60 days	6 (20.7%)	0.77 (0.23 – 2.26)	0.08			

† Data not available for all individuals, significant at 95% ($p<0.05$) are highlighted in bold, *adjusted odds rates (AOR) are only presented for those variables included in the final regression mode

5 Patterns of Migration and Migration Risks With Leprosy Infection in Maranhão, Brazil †

Christine Murto (1,2), Frédérique Chammartin (1,2), Karolin Schwarz (3), Lea Marcia Melo da Costa (4), Charles Kaplan (5), Jorg Heukelbach, J (6,7)*

1. Swiss Tropical and Public Health Institute, Basel, Switzerland
2. University of Basel, Basel Switzerland
3. University of Cologne, Cologne, Germany
4. Leprosy Control Program; State Health Secretariat of Maranhão, Sao Luis, Brazil
5. University of Southern California, School of Social Work, Hamovitch Center for Science in the Human Services
6. Federal University of Ceará, Fortaleza, Brazil
7. Anton Breinl Centre for Public Health and Tropical Medicine, James Cook University, Townsville, Australia

*** Corresponding author**: Prof. Jorg Heukelbach, Departamento de Saúde Comunitária, Faculdade de Medicina, Universidade Federal do Ceará, Rua Professor Costa Mendes 1608, 5. andar, Fortaleza CE, 60430-140, Brazil. Phone: ++55-85-33668045; Fax: ++55-85-33668050. Email: heukelbach@web.de

† This publication is part of the MAPATOPI study (an interdisciplinary project providing evidence for improving the Brazilian leprosy control program), co-financed by the Brazilian Research Council (CNPq) and the Department of Science and Technology of the Brazilian Ministry of Health (DECIT).

This article has been published in

PLoS Neglected Tropical Diseases, 7(9)
September 5, 2013

5.1 Abstract

Leprosy remains a public health problem in Brazil with new case incidence exceeding World Health Organization (WHO) goals in endemic clusters throughout the country. Migration can facilitate movement of disease between endemic and non-endemic areas, and has been considered a possible factor in continued leprosy incidence in Brazil. A study was conducted to investigate migration as a risk factor for leprosy. The study had three aims: 1) examine past five year migration as a risk factor for leprosy 2) describe and compare geographic and temporal patterns of migration among past 5-year migrants with leprosy and a control group, 3) examine social determinants of health associated with leprosy among past 5-year migrants. The study implemented a matched case-control design and analysis comparing individuals newly diagnosed with leprosy (n=340) and a clinically unapparent control group (n=340) without clinical signs of leprosy, matched for age, sex and location in four endemic municipalities in the state of Maranhão, northeastern Brazil. Fishers exact test was used to conduct bivariate analyses. A multivariate logistic regression analysis was employed to control for possible confounding variables. Eighty cases (23.5%) migrated 5-years prior to diagnosis, and 55 controls (16.2%) migrated 5-years prior to the corresponding case diagnosis. Past 5 year migration was found to be associated with leprosy (OR: 1.59; 95% CI 1.07 – 2.38; p=0.02), and remained significantly associated with leprosy after controlling for leprosy contact in the family, household, and family/household contact. Poverty, and leprosy contact in the family, household and other leprosy contact was associated with leprosy among past 5-year migrants in the bivariate analysis. Alcohol consumption was also associated with leprosy, a relevant risk factor in susceptibility to infection that should be explored in future research. Our findings provide insight into patterns of migration to localize focused control efforts in endemic areas with high population mobility.

5.2 Introduction

Leprosy continues to be an endemic disease in many parts of the world. Brazil has globally the second highest new case incidence (WHO, 2011). National leprosy prevalence of 1.54/10,000 in 2010 (Brasil MoH, 2010) remains above the WHO goal of <1 per 10,000. Highly endemic areas of the disease continue to persist despite large-scale national efforts to control the disease. A challenge in disease control efforts is compounded as leprosy can be diagnosed many years after infection took place due to the long incubation period, and mild early symptoms of the disease may be overlooked. Migration has been found to be a social determinant of disease (Aagaard-Hansen, Nombela & Alvar, 2010), and has been hypothesized as a risk factor in continued leprosy incidence (Kerr-Pontes, Montenegro, Barreto, Werneck & Feldmeier, 2004; Magalhães & Rojas, 2007; Penna & Oliveira, 2009). In fact, earlier research in Brazil highlighted the increased distribution of leprosy along new corridors coinciding with frontier expansion connecting southern agricultural areas to the north of Brazil (Martelli, et al., 1995), as well as periurban migrant settlements on the outskirts of urban centers (Kerr-Pontes et al., 2004). Migrants move between endemic and non-endemic areas in Brazil and often live in substandard conditions. As an infectious disease caused by *Mycobacterium leprae*, leprosy primarily affects the skin and peripheral nerves and causing sensory loss. While nasal mucosa is considered the main transmission site, new research indicates that oral presence of *M.leprae* bacilli may be an additional mode of transmission (Martinez et al.,2011). Maranhão, the study area of this research, has the third highest prevalence of leprosy (5.34/10,000) in the country (Brazil MoH, 2010) and is among the states with the highest out- and return- migration rates (IBGE, 2009).

The proliferation of leprosy in Brazil continues largely in conditions of poverty that include poor housing and sanitation, high household density, illiteracy and low socioeconomic levels both at the micro and macro levels (Kerr-Pontes et al., 2004; Cury et al., 2012; Kerr-Pontes et al., 2006; Ferreira, Ignotti & Gamba, 2011; Montenegro, Werneck, Kerr-Pontes & Feldmeier, 2004). Rapid population growth and uncontrolled urbanization, often as a consequence of migration for employment and differential access to services between rural and urban areas, has facilitated the expansion of these poor social and environmental conditions on the peripheries of cities associated with leprosy infection (Kerr-Pontes et al., 2004; Montenegro et al., 2004; Magalhães & Rojas, 2007; Martelli, et al., 1995; Montenegro et al., 2004). Additionally, new road construction and railways have enabled movement between rural communities and urban areas. These developments in transportation have been argued to explain the expanded distribution of leprosy in Brazil (Kerr-Pontes et al., 2004; Montenegro et al., 2004; Magalhães & Rojas, 2007; Penna & Oliveira, 2009). Nevertheless,

household leprosy contact continues to be the primary risk factor associated with leprosy infection (Sales, et al., 2011). Proximity to the household contact has been seen as relevant in terms of increased risk (Moet, Pahan, Schuring, Oskam & Richardus, 2006). Consanguineous contact has also been found to be associated with leprosy. Findings from Moet et al. (2006) suggest evidence of a genetic relationship independent of physical contact for leprosy infection.

Migration has been found to be an impediment to both leprosy elimination and control efforts. Prior research has suggested that migration may influence transmission and distribution of the disease (Magalhães & Rojas, 2007; Penna & Penna, 2009) as well as other neglected tropical diseases (NTDs) (Aagaard-Hansen, Nombela & Alvar, 2010; Watts, 2006; Kloos et al., 2010; Drumond & Marcopito, 2006; Bedoya-Pacheco et al., 2011; Coura & Junqueira, 2012; Drumond & Costa, 2011; da Silva-Nunes et al., 2008). This study explores the spatial and temporal patterns of migration in individuals with leprosy in Maranhão. The study also examines risk factors associated with leprosy among individuals who have migrated in the past five years (past 5-year migrants). Comparison of risks associated with leprosy and migration is challenging in a homogeneous population. However evaluation of specific risk factors that differentiate leprosy among past 5-year migrants from a clinically unapparent control group without clinical signs of leprosy who migrated in the past five years in this investigation, sheds light on those factors that are of importance when considering leprosy infection and expression of disease. The study has three specific aims: 1) to examine if migration in the past five years is a risk factor for leprosy; 2) to describe and compare geographic and temporal patterns of migration among past 5-year migrants with leprosy and a control group without clinical signs of leprosy; 3) to examine the social determinants of health associated with leprosy among past 5-year migrants.

5.3 Methods

5.3.1 Ethics Statement

Written approval was obtained from the Ethical Review Board of the Federal University of Ceará (Fortaleza, Brazil). Permission to perform the study was also obtained by the Maranhão State Health Secretariat, the State Leprosy Control Program and municipalities involved. Informed written consent was obtained from study participants, or their parent/guardian in the case of minors, after explaining the objectives of the study. Interviews were conducted in private.

5.3.2 Study area

The research was conducted in four leprosy endemic municipalities in the state of Maranhão, Brazil: Santa Inês, São José de Ribamar, Codó, and Bacabal. These municipalities are located in a major endemic cluster identified by the Brazilian Ministry of Health as a high-risk area for leprosy transmission (Penna & Penna, 2009). Santa Inês, (population 77,282) (IBGE, 2012), Codó (population 118,038) (IBGE, 2012), and Bacabal (population 100,014) (IBGE, 2012) are small townships in the interior of Maranhão that are largely surrounded by rural agricultural production, while São José de Ribamar (population 163,045) (IBGE, 2012) is on the outskirts of the capital city, São Luis. Most households are small brick or mud and palm residences with rudimentary plumbing and hammocks to accommodate the multigenerational inhabitants.

5.3.3 Study design

A case-control study was designed as part of an extended epidemiological investigation on risk factors associated with leprosy infection in four highly endemic municipalities in Maranhão, as part of the MAPATOPI study. The MAPATOPI study is an interdisciplinary project to support and improve the Brazilian leprosy program in Maranhão, Pará, Tocantins, and Piaui. Variables associated with past five year migration among those diagnosed with leprosy between 2009-2010 were compared with a matched clinically unapparent control group without clinical signs of leprosy. Migration was defined as those who resided outside of the municipality of their current residence, and is limited to five years as this is the average incubation period from leprosy infection to symptom onset. Past five year migration data is also collected in the Brazilian National Household Survey (IBGE 2009). A detailed analysis of socio-cultural, health service related and economic variables that were collected as part of the larger epidemiological study will be explored elsewhere.

5.3.4 Study sample

The case group was identified through the database of the National Information System for Notifiable Diseases (*Sistema de Informação de Agravos de Notificação* – SINAN) and included adults 15 and older in each of the four sites diagnosed with leprosy in 2009-2010 (n=394). Individuals under 15 years of age, those previously diagnosed with leprosy and relapsed, living outside of the highly endemic cluster and who could not be located through multiple contact attempts were excluded from the study. The control group (n=391) was selected from the *Programa Saúde da Família* (Program for Family Health). This program registers all families in the catchment areas of the clinic by community health workers. At the clinics, we randomly selected intake forms from the

Program for Family Health for age and sex at each clinic and contacted those individuals for inclusion in the control group. Each of the matched controls were clinically evaluated for signs of leprosy. Any individual with a clinical suspicion of leprosy was excluded from the study and referred to municipal health centers for further diagnostic testing.

5.3.5 Data collection

Data collection was conducted between April and August 2010. Data collection was coordinated through the Municipality Health Secretariats with the support of the Maranhão State Health Secretariat. Study participants were recruited by community health agents for the study. They were interviewed by trained health professionals at the local health care centers, or in patient homes when disability or age prevented health center attendance. Information on demographics, socioeconomic status, healthcare access, migration, behavior and stress was collected through structured questionnaires. Clinical data were also collected through patient medical records.

5.3.5 Data analysis

Data were entered twice using EpiInfo software version 3.5.1 (Centers for Disease Control and Prevention, Atlanta, USA) and cross-checked for entry-related errors. Statistical tests were used to assess normality. Included are data sets with information related to migration. Any cases that did not have complete migration data were excluded from the analysis. Of the 340 leprosy cases and 340 matched controls, we first identified 135 (19.9%) past 5-year migrants in the case (n=80) and control groups (n=55). The distribution of key demographic, spatial and temporal migration pattern variables among past 5-year migrants in the case and control groups was examined and tested by the use of Fishers exact test for significant differences in the stratified sample of past 5-year migrants.

We then conducted bivariate analyses comparing cases (n=340) and controls (n=340) using Fishers exact test to examine if past five year migration was associated with leprosy diagnosis. As household contact remains the most significant known transmission risk to date for leprosy infection (Sales et al., 2011; Moet et al., 2006), we additionally undertook multivariate logistic regression analysis controlling for family (parent, child and/or sibling) and household (consanguineous and/or non-consanguineous) contact with leprosy.

Next, stratified bivariate analyses using Fishers exact tests were used to determine differences in the association among social determinants of health (socioeconomic status), psychosocial (alcohol use

and life stressors) and biosocial factors (leprosy contact exposure) for case and control groups of past 5-year migrants (n=135).

5.4 Results

A total of 394 leprosy cases and 391 controls were interviewed. There were 23 relapsed leprosy cases and 12 controls suspected of leprosy who were excluded from the study. Eight respondents refused to participate. Complete migration data was available for 680 respondents. Of the 340 leprosy cases and 340 matched clinically unapparent controls, 23.5% of those with leprosy (n=80 cases) and 16.2% (n=55) of the control group without clinical signs of leprosy migrated in the past 5 years before diagnosis. Only 4.4% (n=15) of cases migrated after diagnosis. Table 1 reflects migration into and out of major endemic clusters identified by the Brazilian Ministry of Health as high-risk areas for leprosy transmission (Penna, Oliveira & Penna, 2009) (Figure 1), and other demographics and migration variables. These variables were not significantly associated with leprosy among past 5-year migrants prior to diagnosis (test results not shown). Leprosy cases were largely among the youngest age group (15-29) migrating, with an equal distribution between males and females. More than one-third of those with leprosy who migrated in the past five years were illiterate. The majority of leprosy cases migrated within cluster 1, which includes the northern states of Pará, Piauí, Tocantins and Maranhão. More than half (56.3%) of cases moved between municipalities in Maranhão, followed with fewer cases to neighboring Pará (11.8%), Piauí (3.9%) and Tocantins (2.0%), and one-fifth of migrants were drawn to non-contiguous states. All those with leprosy migrated into a highly endemic cluster on at least one occasion, not including their current residence.

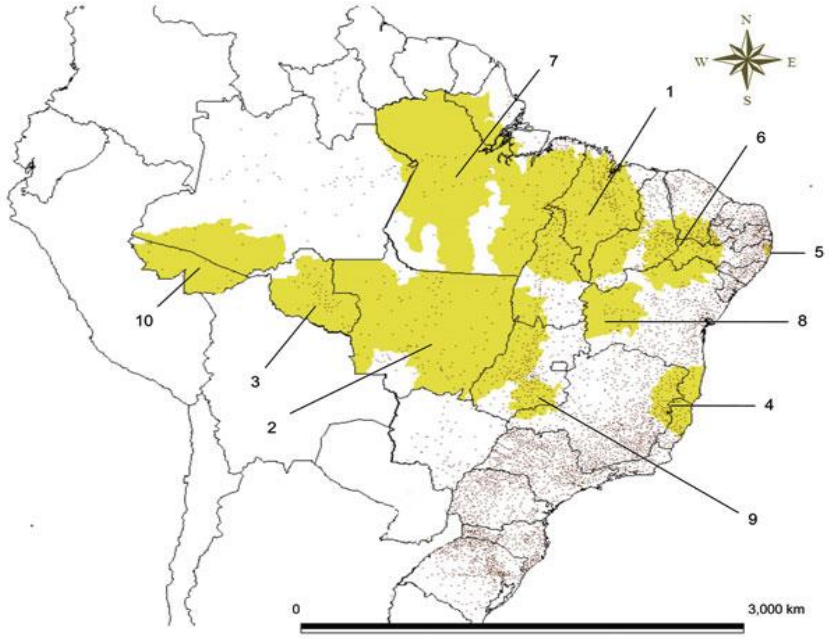


Figure 5.1: Locations of the 10 most probable leprosy clusters (yellow regions) and municipal councils (dots), Brazil, 2005–2007. (Penna, Oliveira & Penna, 2009)

Nearly one in six migrants with leprosy migrated for employment in the last five years and this was slightly less than expected for internal population movement. Typical of internal population flow, most migration in Maranhão was to urban areas (60.3%) compared to rural areas (33.3%), and both rural and urban areas (7.7%). Social networks in migration destination sites for those with leprosy had a higher tendency to be family contacts with whom they lived (81.0%) than work contacts (17.7%). This may be an explanation for the significant number of respondents who always had a contact prior to migrating (79.8%). Migrants with leprosy lived on average with 8.61 people per household while migrating.

Past five year migration prior to diagnosis was found to be significantly associated with leprosy as shown in Table 2 which represents the results of the multivariate logistic regression analysis. Past five year migration remained significantly associated with leprosy after controlling in separate models for 1) household contact (consanguineous and/or non-consanguineous); 2) family contact (parent, child and/or sibling; 3) and household and family contact in multiple logistic regression models.

Key social, biosocial, and behavioral factors were found to be associated with leprosy (Table 3). Household, familial and other contact with someone infected with leprosy was significantly different

for leprosy infected past 5-year migrants compared to control group migrants. Genetic association of closely related kinship shows a significant difference for contact with parent/child/sibling (OR: 7.82; CI 95%: 2.32 – 33.38; P-value=0.0001). Contact regardless of consanguinity (OR: 4.99; CI 95%: 1.7 – 16.51; P-value=0.001) and actual household contact (OR: 5.54; CI 95%: 1.49 – 30.46; P-value=0.004) was also significant. An important behavioral factor distinguishing migrants with leprosy compared to the clinically unapparent control group was past five year alcohol consumption (OR: 4.46; CI 95%: 1.43 – 14.15; P-value=0.005).

Income and other socioeconomic variables showed significant differences between migrants with leprosy and the control group. Income less than the minimum wage (OR: 2.12; CI 95%: 0.97 – 4.71; p-value=0.049) as well as poor access to public waste services (OR: 3.1; CI 95%: 1.1 – 10.02; p-value=0.03) and family illiteracy (OR: 2.67; CI 95%: 1.13 – 6.51; p-value=0.02) were found to be associated with leprosy among past 5-year migrants.

Education, presence of BCG scar, zone of residence and lifestyle stressors - separation from family and friends, loss of employment or income, marital separation or death of close friend or relative- were not significantly associated with leprosy among past five year migrants.

5.5 Discussion

Leprosy was introduced to Brazil through European colonization and later through slave movement so that by the 1600's, leprosy was well established in the country (Scott, 1943). More recently, migration has been hypothesized to be an impediment to leprosy control, and spatial analysis indicates the introduction of leprosy through inter and intra-state population movement in Brazil (Magalhães & Rojas, 2007), as well as expanded distribution of leprosy through migration (Opromolla, Dalben & Cardim, 2006). Population movement can put both migrants and non-migrants at risk when diseases move between endemic and non-endemic areas. Latent symptomology, characteristic of leprosy, could facilitate the distribution of disease when no symptoms are present, or when mild symptoms are overlooked. The migrant lifestyle poses similar marginalized socioeconomic, behavioral and environmental risks that have been well established as factors associated with leprosy transmission (Kerr-Pontes et al., 2004; Cury et al., 2012; Kerr-Pontes et al., 2006; Ferreira et al., 2011; Montenegro et al., 2004; Lustosa, Nogeira, Pedrosa, Teles & Campelo, 2011; Silva, Ignotti, Souza-Santos & Hacon, 2010).

Leprosy in this study was found to be significantly associated with past five year migration. Susceptibility among migrants may, in part, be due to spatial and temporal patterns of movement in and between areas identified by the Brazilian Ministry of Health as highly endemic clusters for leprosy transmission (Penna & Penna, 2009). While we found no significant difference between key spatial and temporal variables and past five year migration among those with leprosy compared to the clinically unapparent control group, more than half of movement for internal migration among those with leprosy was within the leprosy endemic cluster in the state of Maranhão. Few migrated to the other nine endemic clusters in Brazil, a third migrated to other non-endemic areas, and less than half migrated outside of Maranhão. From an operational perspective for leprosy control in Brazil, this provides sufficient evidence to suggest future surveillance of population flow between municipalities in Maranhão, which should involve comparison of the distribution of leprosy incidence over the five year latency period. Should these areas be identified as emerging endemic areas, service delivery strategies should target these as focal points for state control efforts.

Maranhão continues to be a state with higher net out- and return- migration (IBGE, 2009). Interstate population movement, such as to neighboring Pará, draws many poor migrants from Maranhão's interior leprosy endemic areas to the employment found in large-scale mining and agriculture (Barros, 2007; Fearnside, 2008). Interstate movement necessitates cross-border cooperation for leprosy control and may aid in identifying impending high-risk areas for disease distribution. In fact, other research showed that 5.2% of leprosy patients in *Cluster 1* (including Maranhão and neighboring states of Tocantins, Piaui and Pará) were diagnosed outside of their municipality of residence between 2001-2009 (Alencar et al., 2012). Municipalities in Maranhão and neighboring Pará, which have the third and fifth highest new case incidence in the country respectively, would be good targets for future collaborative surveillance projects.

Our findings indicate that the majority of migration in Maranhão continues to be between rural and urban areas, consistent with other research on population flow in Brazil (Golgher, Rosa & Araujo Jr., 2008). However population movement documented in our study appears to be of longer duration than is typical for temporary circular migration. Rural to urban migration is a common solution to reduce poverty, as more and regular job opportunities tend to exist in urban areas (Deshingkar, 2008; Hossain, 2001; IOM, 2005). This often places migrants at higher risk for disease morbidity and mortality due to poor living conditions in urban slums (Islam & Azad, 2008). Kerr-Pontes et al.'s (2004) ecological study in Brazil's northeast demonstrated that urban population growth due to uncontrolled urbanization and migrant influx from Brazil's rural interior was a predictor of leprosy incidence.

We found that population movement is clearly facilitated through strong destination based social networks as a precursor to migration. These social networks tend to be family-based, as indicated by migrant co-habitation arrangements. On an individual level, social networks enable population movement by reducing the cost of migration through benefits such as established shared housing and employment networks, thus making migration a more attractive option to pursue. On a community level, social networks that facilitate migration can have a cumulative effect in sending municipalities to perpetuate and build upon migrant flow between origin and destination sites (Massey, 1990). Because of the social nature of these community relationships to kinship, friendships and working relationships, migration can be highly localized to movement between specific neighborhoods in sending and receiving communities.

Short-term movement, as Skeldon (2003) points out, is less likely to be measured through census surveys, thus monitoring population movement should be undertaken at the municipality level and integrated into larger databases to establish early warning systems.

Exposure to an index patient has been identified as the primary determinant of leprosy infection among their contacts. The magnitude of the effect of contact in our study was highest among close family contact – parent, child, and/or siblings - followed by consanguineous and/or non-consanguineous household contact and lastly other contact, which could include social and distant family exposure. The possibility of genetic susceptibility to leprosy infection, through close family kinship has been significantly associated with leprosy among contacts (Sales et al., 2011; Moet et al., 2006; Durães, Guedes, Cunha, Magnanini & Oliveira, 2010) which supports our findings of leprosy association with close kinship among past 5-year migrants. At the household level, other research has shown that proximity to and intensity of exposure to leprosy increases the risk of transmission, as much as five to nine times that of non-household contacts (Sales et al., 2011; Moet et al., 2006; Durães et al., 2010; Fischer, de Vlas, Meima, Habbema, Richardus, 2010; Fine et al., 1997; van Beers, Hatta & Klatser, 1999), although leprosy clustering among neighboring residences in areas of high population density and poverty has social contact risk similar to household contacts (Moura et al., 2013). Contact with multibacillary diagnosis in the household has also been associated with increased risk (Sales et al., 2011; Moet et al., 2006; Fine et al., 1997; van Beers et al., 1999) and indicates late diagnosis and long-term exposure to contacts. As the majority of migrants in our sample were diagnosed with multibacillary leprosy, this has significant implications for transmission and also for leprosy associated complications and disability.

Migration was significantly associated with leprosy in our logistic regression models controlling for household and close family contact independently. The independent association with household and close consanguineous exposure could indicate some relationship to familial social networks in migrant destination sites. This, in addition to intensity of exposure due to high household density during migration, suggests both the genetic relationships and social environment surrounding migration may figure prominently in explaining leprosy diagnosis.

The majority of individuals in contact with an index patient are not susceptible to the disease. As such, Sales et al. (2011) suggest that leprosy surveillance should explore multiple factors that may contribute to the risk for infection. While many behavioral, demographic, and socio-environmental variables were included in the analysis, we found socioeconomic status and past five year alcohol consumption among migrants with leprosy were significantly associated with leprosy in comparison to clinically unapparent migrants in the control group. Brazil has one of the highest alcohol-attributable disability-adjusted life years (DALYs) in the world. According to the World Health Organization, there is evidence for an association between alcohol consumption and infectious disease (WHO, 2011). Current alcohol use however was not significant. This may be the result of recently diagnosed migrants abstaining from alcohol use due to multi-drug therapy treatment. A substantial concern, however was that nearly one in five migrants with leprosy were currently drinking alcohol, which has been associated with leprosy relapse in Brazil (Ferreira et al., 2011). Alcohol consumption can interact with medication absorption (Weathermon & Crabb (1999) and could render leprosy treatment less effective. This can contribute to the elevation of risk for transmission to exposed contacts.

Low socioeconomic status was additionally associated with leprosy among past 5-year migrants. Other research in *Cluster 1* also found poverty associated with migration prior to diagnosis among those with leprosy (Murto et al., 2013). While poverty is ubiquitously associated with leprosy throughout the literature, it should be noted that these results were taken after the migration period and thus may not be an adequate measure of socioeconomic level during migration. Low socioeconomic status among migrants with leprosy may be linked to restricted employment as the result of disability due to leprosy, or difficulty in sustaining employment during treatment. Despite this, family illiteracy and inaccessibility to public waste collection, proxies for low socioeconomic status in Brazil, were significantly higher for migrants with leprosy compared to the control group. Socioeconomic status, the primary social determinant of health, should be the topic of further investigation both during and after migration.

5.6 Conclusion

Leprosy was found to be associated with past five year migration, even after controlling for confounders. In the comparison of past 5-year migrants, leprosy was associated with both household consanguineous and/or non-consanguineous contact, close family and other social leprosy contact, consistent with research identifying contact exposure as the major determinant of leprosy transmission (Sales et al., 2011; Moet et al., 2006). However, the magnitude of effect for leprosy among migrants in our study was most significant among close family and household contacts. As migration in Maranhão was largely facilitated through family networks, contact surveillance should include migration site residence contacts as well as current residence contacts.

While patterns of migration, including movement in and between highly endemic clusters, were not different among migrants with leprosy and clinically unapparent migrants in the control group, important facets of migration emerged that could benefit leprosy control at the state and national level. State control programs should consider monitoring past five year residence among those newly diagnosed with leprosy to identify intra- and inter-state migration flow. This may provide early warning systems for localized disease control in areas yet to be identified as high-risk areas.

Alcohol consumption in the years prior to diagnosis may be associated with susceptibility to leprosy. Alcohol consumption and consumption frequency should be included in future investigations. This research will help to determine the extent that alcohol consumption plays a role in the dynamics of both transmission and expression of leprosy. As alcohol consumption has also been associated with leprosy relapse, further attention should be given to alcohol consumption during treatment, patient relapse and contact exposure to leprosy. Other substances should also be given attention in future research.

Other research in Brazil has found a spatial relationship to migration and distribution of leprosy and an association of leprosy with poor socio-economic conditions (Kerr-Pontes et al., 2004; Magalhães & Rojas, 2007; Penna, Oliveira & Penna, 2009). Our research shows that in endemic areas leprosy is not only associated with population movement itself, but, most importantly with the social conditions of the migrant in the endemic areas, their behavior, and contact with leprosy in the family and household.

5.7 Acknowledgements

We thank the entire team of the Leprosy Control Program and the State Health Secretariat of Maranhão. Collaboration of the Municipalities' Health Secretariats and Primary Health Care Centers is acknowledged. Special thanks to Professor Marcel Tanner, Director of the Swiss Tropical and Public Health Institute (SwissTPH) for guidance in the methodological approach and final review, Dr. Penelope Vounatsou (SwissTPH) for guidance on the statistical analysis, and Dirk Keidel of SwissTPH for assistance with data management. We are most grateful to all patients that kindly agreed to participate in the study.

This publication is part of the MAPATOPI study (an interdisciplinary project providing evidence for improving the Brazilian leprosy control program).

Table 5.1: Demographics and migration patterns of past 5-year migrant leprosy cases and clinically unapparent controls

	Leprosy Cases		Controls	
	Included*(n=80)†	%	Included (n=55)†	%
Demographics				
Age				
15-29	35	43.8	28	50.9
30-44	21	26.3	14	25.5
45-59	15	18.8	9	16.4
60 or older	9	11.3	4	7.3
Gender				
Male	40	50.0	35	63.6
Female	40	50.0	20	36.4
Education				
Literate	54	67.5	45	81.8
Illiterate	26	32.5	10	18.2
Migration Patterns				
Leprosy Cluster Migration				
Cluster 1	48	60.0	32	58.2
Cluster 2	3	3.8	1	1.8
Cluster 6	1	1.3	0	0
Cluster 7	1	1.3	1	1.8
Cluster 9	2	2.5	0	0
Out of cluster migration	25	31.3	21	38.2
Migration in cluster				
1 time	71	88.8	49	89.1
2 or more times	9	11.3	5	9.1
In-state vs. out of state migration				
In Maranhão	45	56.3	25	45.5
Other state	35	43.75	30	54.6
No. of times migrated past 5-yrs				
1 time	61	76.3	47	85.5
2 or more times	19	23.8	8	14.5
Zone of migration in past 5-yrs				
Urban only	47	60.3	38	70.4
Rural only	26	33.3	13	24.1
Rural and Urban	6	7.7	3	5.6
Migration for work in past 5-yrs				
Yes	46	57.5	30	55.6
No	34	42.5	25	45.5
Social network prior to migration				
Always	63	79.8	39	70.9
Sometimes	5	6.3	1	1.8
Never	11	13.9	15	27.3
Who lived with during migration				
Family	64	81.0	41	74.6
Co-workers	14	17.7	12	21.8
Other	1	1.3	2	3.6
Mean # people lived with during migration	80	8.61	55	6.7
Mean years of migration		6.25		4.8

† Data not available for all individuals

Table 5.2: Crude (OR) and adjusted odds ratios (AOR) for the association of leprosy and five year migration prior to leprosy diagnosis, controlling for household, family, and household and family leprosy contact

					AOR Controlling for leprosy contact		
	Included (n=680)	Leprosy Cases N (%)	Controls N (%)	OR (95% CI)	Household contact	Family contact	Household/Family contact
Past five year migration							
Yes	135	80 (59.3)	55 (40.7)	1.59 (1.07 – 2.38)*	1.54 (1.03 – 2.29)*	1.51 (1.01 – 2.27)*	1.51 (1.0 – 2.28)**
No	545	260 (47.7)	285 (52.3)	1.0	1.0	1.0	1.0

*P < .05
**P<.10

Table 5.3: Factors associated with leprosy diagnosis among past five year migrant cases and clinically unapparent controls

Social and Behavioral Variables	Included (n=135) ††	Leprosy Cases N (%)	Controls N (%)	OR (95% CI)	P-value
Alcohol consumption					
Never drank	29	15 (51.72)	14 (48.28)	Reference	
Drink currently	43	15 (34.88)	28 (65.12)	0.5 (0.17 – 1.45)	0.22
Drank in past 5 years	52	43 (82.69)	9 (17.31)	4.46 (1.43 – 14.15)	0.005
Stopped drinking more than 5 years ago	11	7 (63.64)	4 (36.36)	1.63 (0.32 – 9.25)	0.72
Leprosy Contact					
Familial and non-familial contact					
No leprosy contact	76	33 (43.42)	43 (56.58)	Reference	
Parent/Child/Sibling with leprosy	28	24 (85.71)	4 (14.29)	7.82 (2.32 – 33.38)	0.0001
Others with leprosy	29	23 (79.31)	6 (20.69)	4.99 (1.7 – 16.51)	0.001
Household contact with leprosy past 5/6 years					
Yes	23	20 (86.96)	3 (13.04)	5.54 (1.49 – 30.46)	0.004
No	108	59 (54.63)	49 (45.37)	Reference	
Socio-economic factors					
Income†					
<=R$510	55	38 (69.09)	17 (30.91)	2.12 (0.97 – 4.71)	0.049
>R$510	76	39 (51.32)	37 (48.68)	Reference	
Public Waste Service					
Yes	107	58 (54.21)	49 (45.79)	Reference	0.03
No	28	22 (78.57)	6 (21.43)	3.1 (1.1 – 10.02)	
Family Illiteracy					
Yes	44	32 (72.73)	12 (27.27)	2.67 (1.13 – 6.51)	
No	78	39 (50.0)	39 (50.0)	Reference	0.02

†At the time of the survey 1US$ was equivalent to 1.72R$, and R$ 511,- the official minimum wage as set by the Federal Government †† Data not available for all individuals

5.8 References

Aagaard-Hansen, J., Nombela, N., & Alvar, J. (2010). Population movement: a key factor in the epidemiology of neglected tropical diseases. *Trop Med Int Health*, 1281-1288.

Alencar, C.H.M., Ramos, A.N., Murto, C., Alencar, M.J.F., Barbosa, J.C., & Heukelbach, J. (2012). Diagnosis of Hansen's disease in municipalities other than the patients' residence: spatial analysis, 2001-2009. *Cadernos de Saúde Pública*, 28 (9).

Barros, C. (2007). Trem de maranhense. *Reporter Brasil*.

Bedoya-Pacheco, S., Araujo-Melo, M., Valete-Rosalino, C., Pimentel, M., Conceição-Silva, F., Schubach, A. & Marzochi, M.C.A. (2011). Endemic tegumentary leishmaniasis in Brazil: correlation between level of endemicity and number of cases of mucosal disease. *Am J Trop Med Hyg. 2011 , 84*(6), 901-5.

Brazil, MoH. (2010). *Indicadores de morbidade e factores de risco. Taxa de prevalencia de hanseniase.* Retrieved from http://tabnet.datasus.gov.br/cgi/deftohtm.exe?idb2011/d0206.def

Coura, J., & Junqueira, A. (2012). Risks of endemicity, morbidity and perspectives regarding the control of Chagas disease in the Amazon Region. *Mem Inst Oswaldo Cruz, 107*(2), 145-54.

Cury, M.R., Paschoal, V.D., Nardi, S.M., Chierotti, A.P., Rodrigues, Jr, A.L., & Chiaravalloti-Neto, F. (2012). Spatial analysis of leprosy incidence and associated socioeconomic factors. *Rev. Saúde Pública , 46*(1), 110-118.

da Silva-Nunes, M., de Souza, V.A., Pannuti, C.S., Sperança, M.A., Terzian, A.C., Nogueira, M., Yamamura A.M., Freire M.S., da Silva N.S., Malafronte R.S., Muniz P.T.,Vasconcelos H.B., da Silva E.V., Vasconcelos P.F., & Ferreira M.U. (2008). Risk factors for dengue virus infection in rural Amazonia: population-based cross-sectional surveys. *Am J Trop Med Hyg. , 79*(4), 485-94.

Deshingkar, P. (2008). Circular Internal Migration and Development in India. In J. DeWind, & J. Holdaway (Eds.), *Migration and Development Within and Across Borders: Reserach and Policy Perspectives on Internal and International Migration* (pp. 161-187). Geneva: IOM and SSRC.

Drumond, J.A., & Marcopito, L.F. (2006). Internal migration and distribution of chagas disease mortality, Brazil 1981-1998. *Cad Saude Publica, 22*, 2131-40.

Drumond, K.O., & Costa, F.A. (2011). Forty years of visceral leishmaniasis in the State of Piaui: a review. *Rev Inst Med Trop Sao Paulo, 53*(1), 3-11.

Durães, S., Guedes, L., Cunha, M., Magnanini, M., & Oliveira, M. (2010). Epidemiologic study of 107 cases of families with leprosy in Duque deCaxias, Rio de Janeiro, Brazil. *An Bras Dermatol, 85*(3), 339-45.

Fearnside, P. M. (2008). The roles and movements of actors in the deforestation of Brazilian Amazonia. *Ecology and Society, 13*(1), 23.

Ferreira, S., Ignotti, E., & Gamba, M. (2011). Factors associated to relapse of leprosy in Mato Grosso, Central-Western Brazil. *Rev Saude Publica, 45*(4), 756-64.

Fine, P., Sterne, J., Ponninghaus, J., Bliss, L., Saul, J., Chihuana, A., Munthali, M. & Warndorff, D.K. (1997). Household and dwelling contact as risk factors for leprosy in Northern Malawi. *Am J Epidemiol, 146*(1), 91-102.

Fischer, E., De Vlas, S., Meima, A., Habbema, D., & Richardus, J. (2010). Different Mechanisms for Heterogeneity in Leprosy Susceptibility Can Explain Disease Clustering within Households . *PLoS One, 5*(11), e14061.

Golgher, A., Rosa, C., & Araujo Jr, A. (2008). Determinants of migration in Brazil: Regional Polarization and Povety Traps. *Papeles de Poblacion*(56), 135-171.

Hossain, M.Z. (2001). *Rural-urban migration in Bangladesh: a micro-level study*. Paper presented at XXIV International Union for the Scientific Study of Population (IUSSP) General Population Conference; Aug 20-24. Salvador, BA Brazil; 2001. http://www.archive-iussp.org/Brazil2001/s20/S28_P02_Hossain.pdf.

Instituto Brasileiro de Geografia e Estatistica (IBGE). (2009). *Pesquisa Nacional por Amostra de Domicílios (PNAD).*

Instituto Brasileiro de Geografia e Estatistica (IBGE) (2010) IBGE Cities. Retrieved from http://www.ibge.gov.br/cidadesat/topwindow.htm?1

International Organization for Migration (IOM). (2005). *Internal Migration and Development: A Global Perspective.* eds. Deshingkar P, Grimm S.

Islam, M., & Azad, K. (2008). Rural-urban migratoin and child survival in urban Bangladesh: Are the urban migrants and poor disadvantaged? *J Biosoc Sci, 40*, 83-96.

Kerr-Pontes, L.R.S., Barreto, M.L., Evangelista, C.M.N., Rodrigues, L.C., Heukelbach, J., & Feldmeier, H. (2006). Socioeconomic, environmental and behavioral risk factors for leprosy in North-east Brazil: results of a case-control study. *Int J Epidemiol, 35*(4), 994-1000.

Kerr-Pontes, L.R.S., Montenegro, A.C., Barreto, M.L., Werneck, G.L., & Feldmeier, H. (2004). Inequality and leprosy in Northeast Brazil: an ecological study. *Int J Epidemiol, 33*, 262-69.

Kloos, H., Correa-Oliveira, R., dos Reis, D.C., Rodriques, E., Monteiro, L.A.S., & Gazzinelli, A. (2010). The role of population movement in the epidemiology and control of schistosomiasis in Brazil: a preliminary typology of population movement. *Mem Inst Oswaldo Cruz, 105*(4), 578-86.

Lustosa, A., Nogueira, L., Pedrosa, J., Teles, J., & Campelo, V. (2011). The impact of leprosy on health-related quality of life. *Rev Soc Bras Med Trop. , 44*(5), 621-6.

Magalhães, M., & Rojas, L. (2007). Spatial Differentiation of Leprosy in Brazil. *Epidemiologia e Serviços de Saúde 2007, 16*(2), 75-84.

Martelli C.M., Moraes Neto, O.L., Andrade, A.L., Silva S.A., Silva I.M., Zicker F. (1995) Spatial patterns of leprosy in an urban area of central Brazil. *Bull World Health Organ* 73(3):315-9.

Martinez, T., Figueira, M., Costa, A., Gonçalves, M., Goulart, L., & Goulart, I. (2011). Oral mucosa as a source of Mycobacterium leprae infection and transmission, and implications of bacterial DNA detection and the immunological status. *Clin Microbiol Infect. 2011 Nov;17(11):1653-8, 17*(11), 1653-8.

Massey, D. (1990). Social Structure, Household Strategies, and the Cumulative Causation of Migration. *Population Index, 56*, 3-26.

Moet, F., Pahan, D., Schuring, R., Oskam, L., & Richardus, J. (2006). Physical distance, genetic relationship, age and leprosy classification are independent risk factors for leprosy in contacts of patients with leprosy. *J of Infec Dis, 193*, 346-53.

Montenegro, A.C., Werneck, G.L., Kerr-Pontes, L.R.S., & Feldmeier, H. (2004). Spatial analysis of the distribution of leprosy in the state of Ceara, Northeast Brazil. *Mem Inst Oswaldo Cruz, 99*(7), 683-86.

Moura, M.L.N., Dupnik, K.M., Sampaio, G.A.A., Nóbrega, P.F.C., Jeronimo, A.K., do Nascimento-Filho, J.M., Miranda Dantas, R.L., Queiroz, J.W., Barbosa, J.D., Dias, G., Jeronimo, S.M., Souza, M.C. & Nobre, M.L. (2013) Active Surveillance of Hansen's Disease (Leprosy): Importance for Case Finding among Extra-domiciliary Contacts. *PLoS Negl Trop Dis,* 7(3): e2093.

Murto, C., Ariza, A., Alencar, C.H., Chichava, O.A., Oliveira, A.R., Kaplan, C, da Silva, L.F.M., & Heukelbach, J. (2013). Migration among individuals with leprosy: A population-based study in central Brazil. Accepted for publication *Cad Saude Publica* August 9, 2013.

Opromolla P.A., Dalben, I., Cardim, M. (2006) Geostatistical analysis of leprosy cases in the state of São Paulo, 1991-2002. *Rev Saude Publica,* 40(5), 907-13.

Penna, M.L.F., Oliveira, M.L.W., & Penna, G. (2009). Spatial distribution of leprosy in the Amazon region of Brazil. Retrieved from http://wwwnc.cdc.gov/eid/article/15/4/08-1378.htm. *Emerg Infect Dis*. 15(4), 650-652.

Penna, M.L.F., & Penna, G. (2009). The epidemiological behavior of leprosy in Brazil. *Lep Rev,* 80, 332-44.

Sales, A., Leon, A., Duppre, N., Hacker, M., Nery, J., Sarno, E.N., & Penna, M.L.F. (2011). Leprosy among patient contacts: A multilevel study of risk factors. *PLOS NTD, 5*(3), e1013.

Scott, Sir H.H. (1943). The influence of the slave trade on the spread of tropical disease.*T Roy Soc Trop Med H.* 37(3): 169-188.

Silva, D.R.X., Ignotti, E., Souza-Santos, R., & Hacon, S.S. (2010). Hanseníase, condições sociais e desmatamento na Amazonia brasileira. *Rev. Panam Salud Publica, 27*(4), 268-75.

Skeldon, R. (2003). Migration and Poverty. In African Migration and Urbanization in Comparative Perspective. Johannesburg, South Africa. June 4-7.

van Beers, S., Hatta, M., & Klatser, P. (1999). Patient contact is the major determinant in incident leprosy: implications for future control. *Int J Lepr Other Mycobact Dis, 67*(2), 119-28.

Watts, S. (2008). *The Social Determinants of Schistosomiasis.* Retrieved from TropIKA.net: http://www.tropika.net/review/051114-Schistosomiasis_Social_Determinants/article.pdf

Weathermon, R., & Crabb, D. (1999). Alcohol and medication interactions. *Alcohol Res Health, 23*(1), 40-54.

WHO. (2011). *Weekly Epidemiological Record , 36*, 389-400.

6 Discussion

The goal of this PhD thesis was to assess the relationship between internal migration and leprosy and social, clinical and behavioral mechanisms that influence both migration among those with leprosy and the disease itself. The agenda for the Brazilian National Leprosy Control Program is a concerted effort to reach WHO elimination goals of less than 1 new case per 10,000 inhabitants/year nationally, increase early diagnosis, and reduce transmission, and the stigmatizing and restrictive disabilities that impede productive lives of those afflicted by advanced disease.

The investigation centering on migration was undertaken to assess 1) factors associated with residence change and migration among those with leprosy (Chapters 2-4), and 2) factors associated with leprosy among past five year migrants (Chapter 5). This PhD thesis synthesizes specific findings on social determinants and behavioral factors associated with migration, patterns of migration, and associated factors relevant for leprosy infection from two endemic states, Maranhão and Tocantins. The study stratifies three categories of migrants: 1) those whose birth residence is different from their current residences; 2) those who have migrated within the past five years, and 3) those that have migrated within the past five years and returned to their place of birth, i.e. circular migrants. This stratification provided rich data on mobile populations throughout the lifecycle of migration, those that migrated within the average 5-7 year latency period for leprosy and those that maintained circular flow between municipalities and states.

Migration was well represented in the study population. The Northeast of Brazil has been the hub of rural to urban migration (Golgher A, Rosa CH, Araujo Jr, AF, 2005) as migrants from impoverished northeastern towns fled to large cities during the last decades and established conclaves of urban villages in the slums of the big cities in southeast of the country. In this study, migrants from birth, individuals that were born in a municipality different from where they are currently residing, represented 76.2% of those newly diagnosed with leprosy from Tocantins, and 66.2% of those from Maranhão; one-fifth (20.9%) were past five year migrants in Tocantins and more than one-fourth (26.7%) in Maranhão, while 10.9% were circular migrants returning to their place of birth.

6.1 Social Determinant of health, health inequities and NTDs

As described in Chapter 1, the social determinants of health encompass those critical circumstances of daily life and structural drivers that are associated with health inequities. In an extensive review

of literature, the most important aspects of the social environment that influence health were outlined: social gradient, stress, early life, social exclusion, work, unemployment, social support, addiction, food and transport (WHO, 2003). The social gradient is reflective of socioeconomic hierarchy that influences inequities in access to resources and health. It has been well established that socioeconomic status is the primary driver of exposure to disease and health inequities (Marmot, 2005; Aagaard-Hansen & Chaignat, 2010; Allotey, Reidpath, & Pokhrel, 2010). The aspects of the daily conditions of poverty such as illiteracy, poor housing, unsanitary living conditions, overcrowding, improper nutrition and the like converge to highlight differential biosocial exposure to health risks for the most vulnerable segments of the population. The Measurement and Evidence Knowledge Network (MEKN) of the WHO Commission on Social Determinants of Health (CSDH) provides an overview of socioeconomic indicators (adapted from Kunst, Bos, & Mackenbach, 2001) that showcase individual, household and regional factors that contribute to socioeconomic measures in an effort to address socioeconomic gaps that can lead to health inequity (Figure 6.1).

Core Indicator	Measured at individual level	Measured at household level	Measured at area level
Education	Highest level completed Number of years of schooling/Literacy	Idem of head of household, partner or parent	% low educated % illiterate Ratio female/male literacy
Occupation	Current occupational class (idem, but lifetime based) (score on social distance scale)	Idem, of head of household	% low class % underemployed % informal sector % unemployed % female population in the labour force
Income	Household members Personal income (work, subsidies, consumption, expenditure)	Household per capita income consumption/expenditure (quintiles or poverty line) Own production	% low income (quintiles or poverty line) Average income Ratio female/male income 10/10 share of income 20/20 share of income Income distribution
Wealth/assets		Total amount of assets/ capital Household per capita wealth (quintiles or poverty line) Housing material conditions (walls, floor and roof) Housing amenities (electricity, radio, bicycle, fuel used) Housing tenure or facilities	% low wealth/assets (quintiles or poverty line) Average wealth 10/10 share of income 20/20 share of income Wealth/assets gradient
Composite	Combination of above indices		Combination of indices

Figure 6.1 Overview of possible socioeconomic indicators to measure health inequities (Bonnefoy, Morgan, Kelly, Butt & Bergman, 2007)

These socioeconomic indicators and social determinants feature factors that are suggested to be included in research to measure health inequities. Many of these have been included throughout this thesis. They are used to build upon the knowledge base of social determinants influencing migration and NTDs. In its framework, the CSDH was tasked to synthesize current findings on social aspects and determinants of health inequities and provide a framework for orientation and actions that lead to reducing health disparities globally. This framework includes: 1) Improving conditions of daily life – the circumstances in which people are born, grow, live, work and age, 2) Tackling the inequitable distribution of power, money and resources – the structural drivers of those conditions of daily life – globally, nationally and locally, and 3) measuring the problem, evaluating action, expanding the knowledge base, developing a workforce that is trained in the social determinants of health, and raising public awareness about the social determinants of health (WHO, 2008). Looking at health through the CSDH lens provides the opportunity to contextualize risk in lives and communities, to develop policy and structure health services that meet the needs of those at highest risk for disease.

In terms of NTDs, as Allotey et al. cite so succinctly, NTDs are "both cause and are the result of poverty" (Allotey, et al., 2010) . A recent extensive review of literature on social determinants of NTDs shows that while social determinants specific to NTDs also include poverty and socio-environmental aspects of poor living conditions, additional associated factors such as migration, crowding, physical environment and sociocultural factors contribute to NTD risk (Aagaard-Hansen & Chaignat, 2010). Showcasing factors associated with migration and disease before and after diagnosis in this thesis also provides an opportunity to view multiple facets of health inequities in this regard.

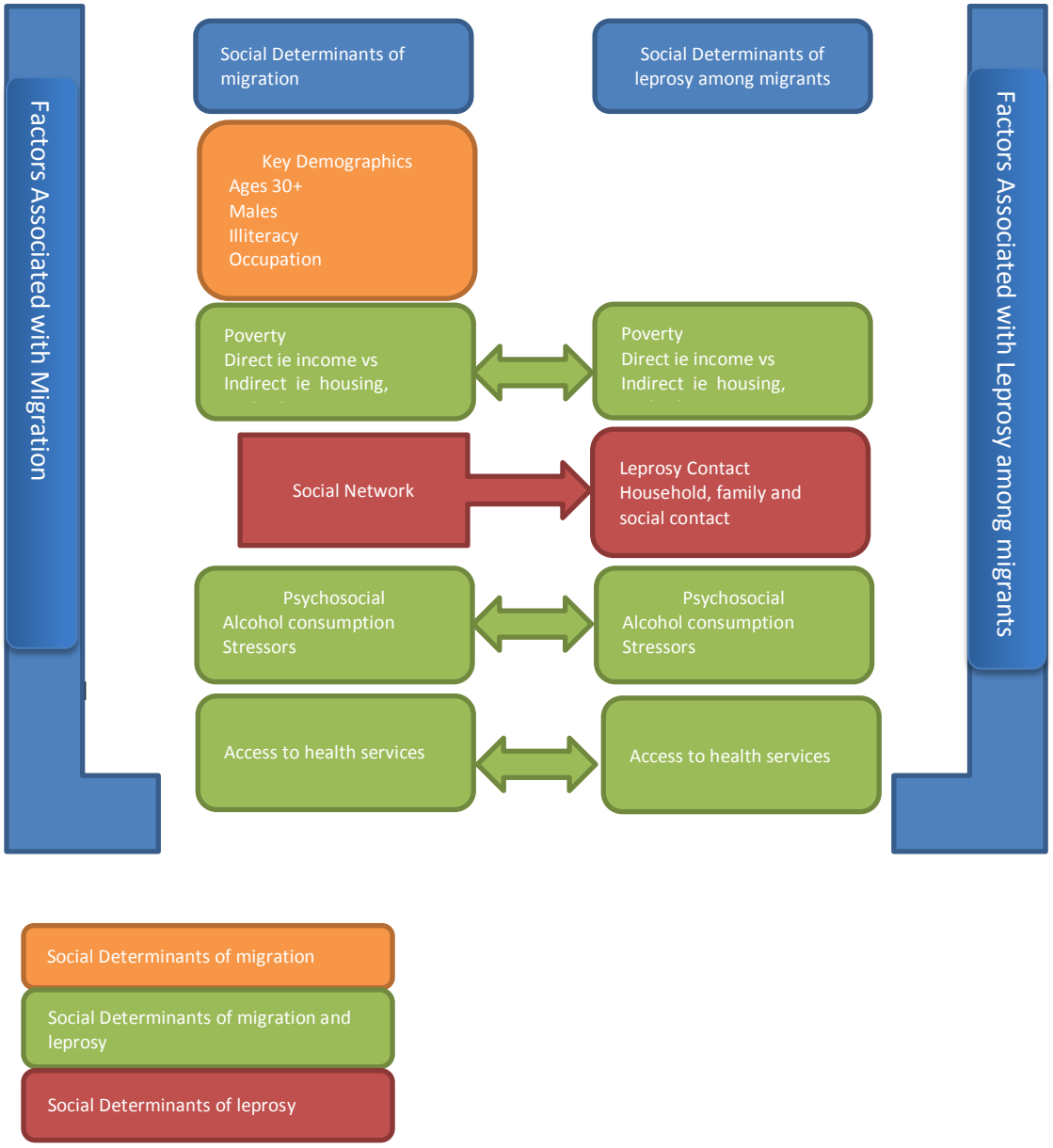
In this PhD thesis, one of the suggested social determinants for NTDs, migration, was explored in detail. We synthesize prior frameworks of migration and the social determinants of health in the context of factors associated with migration among those with leprosy in order to present a new model to increase the understanding of the drivers of migration and those social elements found to be associated with NTD risk.

6.2 Social Determinants of Migration and Leprosy

The framework developed as a result of this research highlights social determinants found to be associated with migration among those with leprosy, and social determinants associated with leprosy among past five year migrants. Key demographics (age, employment, education) were

associated with migration. Poverty was both directly and indirectly associated with both migration and leprosy. Social networks, also long known to be affiliated with migration and recognized throughout the literature, were found to be associated with leprosy. Psychosocial and behavioral factors were relevant for both migrants and leprosy. Finally, access to health services was associated with migration in general and affects those with leprosy.

Figure 6.2 Leprosy and migration framework



6.2.1 Poverty

Poverty is the most important driver of migration throughout the developing world and is the overarching condition of the multitude of inequities associated with leprosy infection (Aagaard-Hansen, Nombela, Alvar, 2010; Allotey, et al., 2010; Kerr-Pontes, et al., 2006). While poor job opportunities and low wages can be structural drivers of migration from low income places of origin to migration destinations (Ackah & Medvedev, 2010; Piotrowski & Tong, 2010; IOM, 2008), structural and individual factors, such as poor education and job skills, often converge to influence migration (Ackah & Medvedev, 2010; IOM, 2005). The relationship between disease exposure and migration throughout the literature often centers on poverty and poor living conditions on the outskirts of urban areas that are the destinations of the rural poor (Kerr-Pontes, Montenegro, Barreto, Werneck, & Feldmeier, 2004; Beguy, Bocquier, & Zulu, 2010; Islam & Azad, 2008) who move to cities for regular employment and access to infrastructure that is well-established in city centers. These precarious living conditions can be further maintained through a continual influx and turnover of migrants engaged in temporary relocation, often between rural and urban areas (Beguy, et al., 2010) where migration is an established practice to mitigate poverty.

In Chapter 5, we showed that recent leprosy infection among past five year migrants in Maranhão was associated with income below the minimum salary (a poverty baseline for Brazil). In addition, not having access to waste services, an indirect indicator of poverty that additionally can include poor housing construction as well as inaccessible services such as electricity, water and other utilities, and improper sanitation is also associated with recent leprosy infection. The relationship between poverty, leprosy and other NTDs is well established (Sales, et al., 2011; Kerr-Pontes, et al, 2006; Aagaard-Hansen & Chaignat, 2010; Manderson, Aagaard-Hansen, Allotey, Gyapong & Sommerfeld, 2009), and the poor are disproportionately represented among those with leprosy. Kerr-Pontes et al.'s ecological study of leprosy in the northeast of Brazil found that in areas of uncontrolled urbanization, the destination of rural migrants, included impoverished conditions that were associated with an increased incidence of leprosy infection (Kerr-Pontes, et al., 2004).

In Chapters 3 and 4, migration among those with leprosy in Tocantins and Maranhão was associated with indirect indicators of poverty, but excluded any association with income when comparing vulnerable populations such as residents and migrants with leprosy. Indirect poverty was most prominent among recent past five year migrants. In fact, other indirect factors typically associated with poverty, such as illiteracy, were negatively associated with migration among recent and circular migrants. As rates of employment among those with leprosy were comparable to the uninfected reference population, other factors beyond poverty should be considered.

What may be important in terms of the intersection between migration and leprosy is attention to relative poverty when considering migrant health risk and socioeconomic status, particularly among recent migrants. Socioeconomic status can change as a result of migration (Hossain, 2001), yet clearly, relative poverty and unequal access to healthy living conditions can continue to place marginal and mobile populations at risk comparable to those in absolute poverty.

Interpretation of poverty among vulnerable migrant populations, such those infected with leprosy, is subject to limitations in cross-sectional studies such as those presented in these chapters. Causal relationships between poverty and disease and poverty and migration have not been established retrospectively in this study. While it is possible that poverty was a driver of migration, it is equally possible that poverty is a result of disease and possibly restricted employment due to leprosy infection. Additionally, the research in Tocantins and Maranhão compared migrants with residents both infected with leprosy, and it is conceivable that vulnerable populations show a high degree of social homogeneity in terms of income, but not indirect indicators, such as living conditions.

Despite these precarious conditions among recent migrants, residence change after diagnosis with leprosy was largely due to positive lifestyle choices. While migration was measured in terms of residence in another municipality, it appears that once established for longer periods of time, migrants may engage in short distance movement to improve living conditions thus possibly reducing the risks associated with disease exposure over time.

6.2.2 Social Networks

Social networks are an important part of the decision to migrate and the process of migration. These networks aid in reducing the cost of migration, an important factor in migration decision-making (Harris & Todaro, 1970). This “social capital” can provide destination-based housing, supportive social and kinship relationships, as well as facilitate employment and other assistance in destination sites (Massey & Espinosa, 1997; Garip, 2008).

At the individual level, migration can be influenced by previous migration (Deléchat, 2001; Massey & Espinosa, 1997), and social networks developed through the migration experience can increase the capability and tenacity in successful migratory transition. At the community level, migration can have the cumulative effect of increasing migration flow between origin communities and established destinations linked through social network contacts (Massey, 1990). In Maranhão, these social networks were strongly facilitated through kinship relationships in the destination sites, which as demonstrated in other research (Deléchat, 2001). In Tocantins, migration influenced multisite

migration after-diagnosis return to birth residence, which could be investigated further to determine community level exchanges along high-flow migration routes.

Established migration routes and flow between origin and destination communities should be considered in leprosy control surveillance. Social network contact notification should additionally be included from prior migration residences, as close household and consanguineous contact exists as a possible risk for leprosy infection as demonstrated in Maranhão. While migration contact notification requires both documentation and coordination between municipal and state public health control programs, it is an important consideration for leprosy control efforts among highly mobile populations.

6.2.3 Psychosocial and Behavioral Factors

There is little research on the role of psychosocial factors and mycobacterial infection. However, we found that these factors were associated with both migration (Chapter 4) and leprosy (Chapter 5). As discussed, family separation due to migration, as well as other stressors (such as job loss and divorce) are significant lifestyle stressors that can compromise immune function rendering one susceptible to disease as well as expressing latent infection symptomology (Cohen & Williamson, 1991; Vivoli, Rovesti, Borella, & Cermelli, 2008).

In Brazil, poverty has led to a historical population movement throughout the last decades (Kaloustian , 1994), often causing family separation when the cost of including family during the migratory phase is not feasible. The process of migration can intensify life stressors and can additionally lead to alcohol consumption as a coping mechanism. Alcohol consumption differentiated migrants from non-migrant residents with leprosy and also was significantly associated with leprosy among past five year migrants in Maranhão. Interestingly, the magnitude of stress from family separation was higher among birth and circular migrants, and the magnitude of alcohol consumption was also higher among these groups than among past five year migrants. The role of psychosocial stressors and alcohol consumption should be the topic of further investigation in terms of its role in susceptibility to leprosy infection, as well as disease expression after exposure since alcohol use has been found to be a major predictor of leprosy relapse in Brazil (Ferreira, Ignotti, & Gamba, 2011).

6.2.4 Access to Health Services

The Brazilian Ministry of Health's Leprosy Control Program decentralized leprosy services at the municipal level public health system in an effort to increase access to services. This system provides diagnosis and treatment free of charge with an emphasis on reducing new case incidence and decreasing disabilities associated with leprosy infection (Souza, el-Azhary, & Foss, 2009). National efforts have included large-scale campaigns to bring awareness of symptoms of leprosy, to reduce the stigmatization associated with the disease, and to guide individuals with symptoms into local public health facilities.

The majority presence of multibacillary leprosy in Tocantins and Maranhão suggests delayed diagnosis despite the availability of these municipal health services. In Tocantins, multibacillary diagnosis was significantly higher among recent migrants. In Maranhão, difficulty in reaching the healthcare facility presents an additional barrier for both diagnosis and subsequent treatment, which could render contacts with those with leprosy susceptible to infection for extended periods of time. While distance and illness were the primary reasons for this difficulty, migration and residence change for the purpose of treatment after diagnosis was minimal.

New residence and unfamiliarity with migration destination locales, as well as distress and alcohol consumption presented in this thesis, can be barriers to seeking health services (Lu, 2010; Storla, Yimer, & Bjune, 2008). In addition, while availability of healthcare facilities contributes to improved health (WHO, 2000), their hours of operation are often incompatible to migrating populations.

Overall findings show that healthcare policies have benefitted patients with localized service provision. However, emphasis on operational changes, such as extended hours and mobile services, could improve early diagnosis and disease management for migrating populations.

6.3 Conclusions

This is the first systematic study of factors associated with migration among those with leprosy and the first to provide evidence that migration is associated with leprosy infection. This research shows a close relationship between risks associated with migration and risk associated with disease, most notably: poverty, recent migration and psychosocial/behavioral factors. Alcohol consumption and lifestyle stressors emerged as uniquely associated with both migration and leprosy infection.

These findings add to the knowledge base for social determinants of NTDs. The results need to be investigated systematically in future research. The study also identified unique risk factors inherent

among migrants that differ from those of resident populations when investigating homogeneous and vulnerable populations. The risk factors, such as health facility access, aid in providing evidence for restructuring health service practices to meet the needs of highly mobile populations. They also provide information on distinct individual behaviors and characteristics, such as alcohol consumption, that can be used in screening instruments for leprosy. In fact, current alcohol consumption patterns and lifestyle stressors and their relationship to leprosy infection should be researched systematically and in-depth. Additionally, operational coordination between municipalities and states with high migrant flow would provide early warning systems for disease distribution and emerging epidemics, not only for leprosy but also for other NTDs.

6.4 References

Aagaard-Hansen, J., & Chaignat, C.L. (2010). Neglected tropical diseases: equity and social determinants. In E. Blas, & A. S. Kurup (Eds.), *In Equity, social determinants and public health programmes.* Geneva: World Health Organization.

Aagaard-Hansen, J., Nombela, N., & Alvar, J. (2010). Population movement: a key factor in the epidemiology of neglected tropical diseases. *Trop Med Int Health*, 1281-1288.

Ackah, C., & Medvedev, D. (2010). *Internal migration in Ghana: Determinants and welfare impacts.* Washington, D.C.: World Bank/West Africa Poverty Reduction and Economic Management Unit (World Bank Policy Research Working Paper Series, 5273).

Allotey, P., Reidpath, D., & Pokhrel, S. (2010). Social sciences research in neglected tropical diseases: the ongoing neglect in the neglected tropical diseases. *Health Res Policy Syst, 8:32*.

Beguy, D., Bocquier, P., & Zulu, E.M. (2010). Circular migration patterns and determinants in Nairobi slum settlements. *Demogr Res, 23*, 549-86.

Bonnefoy, J., Morgan, A., Kelly, M.P., Butt, J., & Bergman, V. (2007). *Constructing the evidence base on the social determinants of health: a guide.* The Measurement and Evidence Knowledge Network (MEKN) (Universidad del Desarrollo, Chile/National Institute for Health and Clinical Excellence, UK). Chile/UK: WHO.

Cohen, S., Williamson, G. (1991). Stress and infectious disease in humans. *Psychol Bull, 109*, 5-24.

Deléchat, C. (2001). International Migration Dynamics: The Role of Experience and Social Networks. *LABOUR, 15*, 457-486.

Ferreira, S.M., Ignotti, E., & Gamba, M.A. (2011). Factors associated to relapse of leprosy in Mato Grosso, Central-Western Brazil. *Rev Saude Publ, 45*(4), 756-64.

Garip, F. (2008). Social Capital and Migration: How Do Similar Resources Lead to Divergent Outcomes? *Demography, 45*(3).

Golgher A, Rosa CH, Araujo Jr AF. The determinants of migration in Brazil In: Proceedings of the 33rd Brazilian Economics Meeting; Niteroi, RJ: ANPEC; 2005. p. 1-20.

Harris, J.R., & Todaro, M.P. (1970). Migration, Unemployment and Development: A Two-Sector Analysis. *Am Econ Rev, 60*(1), 126-142.

Hossain, M.Z. (2001). *Rural-urban migration in Bangladesh: a micro-level study*. Paper presented at XXIV International Union for the Scientific Study of Population (IUSSP) General Population Conference; Aug 20-24. Salvador, BA Brazil; 2001. http://www.archive-iussp.org/Brazil2001/s20/S28_P02_Hossain.pdf.

International Organization for Migration (IOM). (2005). *Internal Migration and Development: A Global Perspective.* eds. Deshingkar P, Grimm S.

International Organization for Migration (IOM). (2008). *World Migration 2008: Managing Labour Mobility in the Evolving Global Economy.* Geneva: IOM.

Islam, M.M., & Azad, K.M. (2008). Rural-urban migratoin and child survival in urban Bangladesh: Are the urban migrants and poor disadvantaged? *J Biosoc Sci, 40*, 83-96.

Kaloustian, S.M. (1994). *Família Brasileira, a Base De Tudo.* Brasilia: Cortez and UNICEF.

Kerr-Pontes, L.R.S., Barreto, M.L., Evangelista, C.M.N., Rodrigues, L.C., Heukelbach, J., & Feldmeier, H. (2006). Socioeconomic, environmental and behavioral risk factors for leprosy in North-east Brazil: results of a case-control study. *Int J Epidemiol, 35*(4), 994-1000.

Kerr-Pontes, L.R.S., Montenegro, A.C., Barreto, M.L., Werneck, G.L., & Feldmeier, H (2004). Inequality and leprosy in Northeast Brazil: an ecological study. *Int J Epidemiol, 33*, 262-69.

Kunst, A.E., Bos, V. & Mackenbach, J.P. (2001). *Monitoring socio-economic inequalities in health in the European Union: guidelines and illustrations*. Rotterdam, Netherlands: Erasmus University, EU Working Group on Socio-economic Inequalities in Health.

Lu, Y. (2010). Rural-urban migration and health: Evidence from longitudinal data in Indonesia. *Soc Sci Med, 70*, 412-19.

Manderson, L., Aagaard-Hansen, J., Allotey, P., Gyapong, M., Sommerfeld, J. (2009). Social Research on Neglected Diseases of Poverty: Continuing and Emerging Themes. *PLoS Neglect Trop D, 3*(2), e332.

Marmot, M. (2005). Social determinants of health inequalities. *Lancet, 365*, 1099–104.

Massey, D. (1990). Social Structure, Household Strategies, and the Cumulative Causation of Migration. *Population Index, 56*, 3-26.

Massey, D.S., & Espinosa, K.E. (1997). What's Driving Mexico-U.S. Immigration? a theoretical, empirical and policy analyisis. *Amer J Sociol, 102*(4), 939-999.

Piotrowski, M., & Tong, Y. (2010). Economic and non-economic determinants of return migration: evidence from rural Thailand. *Population, 65*, 333-48.

Sales, A.M., Leon, A.P., Duppre, N.C., Hacker, M.A., Nery, J.A., Sarno, E.N., & Penna, M.L. (2011). Leprosy among patient contacts: A multilevel study of risk factors. *PLoS Negl Trop D, 5*(3), e1013.

Souza, A.D., el-Azhary, R.A., & Foss, N.T. (2009). Management of chronic diseases: an overview of the Brazilian governmental leprosy program. *Int J Dermatol, 48*, 109-16.

Storla, D.G., Yimer, S., & Bjune, G.A. (2008). A systematic review of delay in the diagnosis and treatment of tuberculosis. *BMC Public Health, 8*.

Vivoli, R., Rovesti, S., Borella, P., & Cermelli, C. (2008). Relation between psychoneuroendocrine profile in stressful conditions and antibodies to herpesvirus 6 and 7. *J Biol Regul Homeost Agents, 22*(4), 239-45.

WHO. (2000). *World Health Report 2000: Health Systems: Improving Performance.* World Health Organization. Geneva: World Health Organization.

WHO. (2003). *The solid facts : social determinants of health.* Centre for Urban Health, edited by Richard Wilkinson and Michael Marmot. Copenhagen : World Health Organization.

WHO. (2008). *Closing the gap in a generation: health equity through action on the social determinants of health. Final Report.* Commission on Social Determinants of Health (CSDH). Geneva: World Health Organization.

Curriculum Vitae

Christine M. Murto

EDUCATION/TRAINING | contact: cmurto@yahoo.com

INSTITUTION AND LOCATION	DEGREE	YEAR	FIELD OF STUDY
Swiss Tropical and Public Health Institute (SwissTPH), Basel, Switzerland	PhD	2012	Epidemiology
California State University, Los Angeles, CA	MA	2002	Medical Anthropology
American University, Washington, DC	BSBA	1988	International Business
USCG Merchant Marine License	Master 50/ton	2001	Maritime Captain
Languages: English (Native), German, Portuguese, Spanish (comprehension)			

Professional Activities and Areas of Interest

- Migrant health
- Neglected tropical disease (NTD), Women's health and HIV
- Social Determinants of health
- Mixed method qualitative and quantitative research
- Strategic planning, program and curriculum development and implementation among migrants, low literacy, underserved and rural populations
- Monitoring and Evaluation

Work Experience

2012-present Co-coordinator/Post-doctorate, Swiss Tropical and Public Health Institute (SwissTPH), Basel, Switzerland. Research on cross-border migration, risk and distribution of American Cutaneous Leishmaniasis (ACL) and Bartonellosis in Acre, Brazil and Madre de Dios, Peru. Participation in project conception, survey design for qualitative/quantitative research with multidisciplinary team investigating patterns of migration between Brazil and Peru, environmental and social risk for ACL/Bartonellosis, and clinical screening for absence of Bartonellosis; field coordination for data collection in conjunction with UPCH (Peru) and UNIFRAN (Brazil); data analysis and publications.

2005-Present Public Health Consultant: Migration and migrant Health/ HIV/Women/NTDs

- Federal University of Ceará, Fortaleza, Brazil – Research Epidemiologist, Leprosy and migration. Field interviews, data analysis and publications. (9/2009-9/2012)

- SCCC, Los Angeles, CA. Lead Evaluator, SAMHSA/CSAT, Assertive Adolescent Family Treatment. Program process and outcome program performance monitoring and evaluation; assessment of adherence to A-CRA/ACC substance abuse treatment model fidelity; implementation and management of client tracking and follow-up for GAIN/GPRA survey; quantitative analysis of program outcomes in reference to National Outcome Measures (NOMS). Qualitative and quantitative research and analysis for quarterly and annual reporting. (9/2010-9/2013)

- SCCC, Los Angeles, CA. Consultant, SAMHSA/CSAP, SA, HIV, & Hepatitis Prevention for Minority Populations. Community stakeholder strategic planning; community needs/risk

assessment; HIV and Hepatitis prevention curriculum development based on risk assessment and strategic plan to guide BSFT model for high risk Latino youth and parents; monitored outcome performance and data integrity. 10/2005-9/2009)

- Central City Neighborhood Partners, Los Angeles, CA. Evaluator. Latino migrant community health education and access for oral health and nutrition. (4/2006-1/2007)

- Los Angeles Family AIDS Network (LAFAN), Los Angeles, CA. Evaluator, Health Resources and Services Administration (HRSA) funded peer driven medication adherence model for underserved women. (4/2004)

2001-2009 Director, AIDSail, Los Angeles, CA

- Central America/Caribbean based programming providing HIV prevention education, clinical screening for HIV/STDs, and domestic violence intervention for women in rural coastal communities in Nicaragua and Jamaica; Management of clinical and community programming and staff, community health worker domestic violence training and taskforce development, integrated qualitative/quantitative community and individual risk assessment, HIV prevention program development and implementation in coordination with National MoH, regional departments of Health and local and international NGOs.
- Post-Katrina program: clinical primary care services for disaster relief, fiscal management, program and staff/medical volunteers administration; deployment of multipurpose teams for community assessments for health, disaster recovery and food relief; strategic planning for migrant HIV prevention and treatment services including research design and implementation and data analysis in coordination with State Office of AIDS and the New Orleans Regional AIDS Planning Council (NORAPC) a federally mandated planning council funded under HRSA/Ryan White.

1999-2005 Program Director/Development, SCCC, Los Angeles, CA - Program management HIV Prevention/Intervention, administration and oversight; staff training; grant writing and development; research. Approximate total budget increase 400%. Research included:

- Office of Minority Health funded program on behavioral risk for HIV, with cognitive assessment of substance using population; model and curriculum development; educator training and program evaluation.
- Centers for Disease Control funded research for prevention among HIV positive individuals to measure the impact of anger management program on HIV risk behaviors among inmates in Los Angeles Country Jails. Responsible for research design implementation, analysis, program coordination, prevention case management.
- City of Los Angeles funded research on domestic violence and HIV among women; research design and field implementation including in-depth qualitative interviews and quantitative interviews; data analysis, report drafting and finalization, data dissemination and conference presentations.

1988-1998 Consumer products, Research Analyst. Product Lines: Patagonia, Inc., Nestle, Quaker Oats, Beiersdorf/Nivea.

Funded Programs and Research

Swiss Network for International Studies (SNIS) 2012-present
Role: Co-coordinator/Post-doctorate Epidemiologist, Migration specialist
Goal: Investigate the relationship between migration and American Cutaneous Leishmaniasis (ACL) and Bartonellosis in the Southwestern Amazon border regions in Brazil and Peru

Brazilian Research Council (CNPq) 9/2009 – 9/2012
MAPATOPI Project, National Program for Leprosy Control
Role: Research Consultant, Migration Specialist
Goal: Determine the association between leprosy and migration through the analysis of patterns of migration, social and environmental determinants and behavioral factors that influence leprosy transmission in Brazil

SAMHSA TI-09-002 10/2010-present
Family Centered Substance Abuse Treatment for Adolescents and their Families
Assertive Adolescent and Family-Centered Treatment for Substance Using Latino Youth in Los Angeles
Role: Lead Evaluator
Goal: Evaluate the use of Adolescent Community Reinforcement Approach (A-CRA) for SUD; assure minimum 80% follow-up data collection; process and outcome evaluation

SAMHSA SP-05-001 2005 – 2009

Substance Abuse, HIV, & Hepatitis Prevention for Minority Populations & Minority Reentry Populations
Role: Consultant
Goal: Evaluate BSFT model to reduce high risk behavior among Latino high-risk and reentry youth

MAC Foundation 2006- 2008

HIV Risk Assessment and Strategic Plan for HIV services for Latino's Post-Katrina New Orleans
Role: Director
Goal: Qualitative and quantitative assessment of HIV risk for among recent Latino migrants engaging in day-labor reconstruction post Hurricane Katrina.

Michael Moore, Producer 2005- 2007

Post-Katrina disaster clinical services
Role: Director
Goal: Provide primary clinical services New Orleans and surrounding communities

United States Office of Minority Health 2004- 2006
Minority community health demonstration project.
Role: Program Director
Goal: Development of culturally sensitive HIV prevention education and testing model for underserved low income, low literacy and Latino migrant populations.

Centers for Disease Control 2002- 2005

CDC PHIPP (Prevention for HIV Infected Individuals) Demonstration Project
Role: Project Director
Goal: Development of anger managements intervention tools and model to reduce HIV transmission among violent and sexually violent incarcerated offenders.

MAC Foundation Completed 2005/Completed 2008

HIV and domestic violence prevention for women in Atlantic coastal communities in Nicaragua and Jamaica
Role: Director
Goal: Development of community and women centered programs that integrate HIV prevention, domestic violence intervention and women managed economic development cooperatives. Rural women's clinics for pelvic exams and HIV testing, clinical risk assessments for HIV/STD's and prevention case management; mixed method HIV KAP and community risk assessments.

City of Los Angeles, AIDS Coordinators Office 2001-2003

Impact of domestic violence on HIV
Role: Researcher
Goal: Determine the association between domestic violence victimization and risk of contracting HIV using a mixed methods approach

Published Reports/Publications

Murto C, Ariza L, Alencar CH, Chichava OA, Oliveira AR, Kaplan C, da Silva LFM, Heukelbach J. Migration among individuals with leprosy: A Population-based study in central Brazil. Accepted for publication August 2013, *Cadernos de Saúde Pública*.

Murto C, Kaplan C, Ariza L, Schwarz K, Alencar CH, da Costa LMM, Heukelbach J (2013). Factors Associated with Migration in Individuals Affected by Leprosy, Maranhão, Brazil: An Exploratory Cross-Sectional Study. *Journal of Tropical Medicine,* 2013 (ID 495076).

Murto C, Chammartin F, Schwarz K, da Costa LMM, Kaplan C, Heukelbach J (2013). Patterns of Migration and Risks Associated with Leprosy among Migrants in Maranhão, Brazil. *PLoS Negl Trop Dis* 7(9).

Alencar CHM, Ramos AN, Murto C, Alencar MJF, Barbosa JC, Heukelbach J (2012). Diagnosis of Hansen's disease in municipalities other than the patients' residence: spatial analysis, 2001-2009. *Cadernos de Saúde Pública*, 28 (9).

Murto C, Ariza L, Oliveira AR, Chichava OA, Alencar CH, da Silva LRM, Tanner M, Heukelbach J (2010). Motives and determinants for residence change after leprosy diagnosis, central Brazil. *Lepr Rev*, 82.

Murto C, Sugimori E, Ullman C, Bowen B (2008). Strategic Plan for Latino HIV/AIDS Prevention and Treatment in New Orleans. New Orleans AIDS Planning Council (HRSA mandated) and AIDSail.

Sa J, Cervantes R,Murto C, Halliday T, Kaplan C (2006). The public health situation and services targeting Latino "transitional" adolescents aged 12-17 and their families residing in Service Planning Area 4 - Metro SPA 4 area of Los Angeles County: A Community Needs Assessment. U.S. Substance Abuse and Mental Health Association (SAMHSA).

Murto C, Sa J (2002). Comparison of Los Angeles and U.S. Incidence of domestic violence in women with HIV. City of Los Angeles, AIDS Coordinators Office.

Conference presentations

2012 "Migration as a Risk Factor for Leprosy, Maranhao, Brazil", American Society of Tropical Medicine and Hygiene, Atlanta, GA

2012 "Factors associated with migration among those diagnosed with leprosy in Central Brazil", International Conference for Tropical Medicine and Malaria, Rio de Janeiro, Brazil

2012 **"**Using focus group data to contextualize evaluation among drug using Latino Youth and their Parents", JMATE, Washington, DC

2007 "Women, Globalization, and HIV/AIDS: Prevention in a Nicaraguan Fishing Town", The Society for Applied Anthropology 67th Annual Meeting, Tampa, FL

2004 "Economic Development in Poor Communities as Prevention for the Spread of HIV", International Conference on HIV/AIDS, Bangkok

2003 "HIV Prevention in a Caribbean Coastal Population", Latino American/ Caribbean FORUM 2003 for HIV/AIDS and STDs, Havana, Cuba

2000 "Correlation between HIV and domestic violence in women", Latino American/ Caribbean FORUM 2000 of HIV/AIDS and STDs, Rio de Janeiro, Brazil