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Type 2 Diabetes Prevalence and Risk Factors of Urban Maasai in Arusha Municipality and Rural Maasai in Ngorongoro Crater

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Authors' contributions

This work was carried out in collaboration between all authors. Author SM co-designed the study, wrote the protocol, managed the literature search, and performed data collection and analysis. Author AN co-designed the study, performed data collection and cleaning. Author PP co-supervised the project at all phases and co-wrote the first draft of the manuscript. Author JB co-supervised the project at all phases and co-wrote the first draft of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aim: The study explored potential impacts of migration on Type 2 Diabetes (T2D) prevalence and risk factors across Maasai ethnic communities living traditional rural lifestyles and those living in an urban environment.
Method: A cross-sectional investigation of 724 adult Tanzanian Maasai participants was conducted. Anthropometric measures (i.e., body mass index; waist-hip ratio; blood glucose, serum lipids) plus lifestyle (i.e., diet/alcohol/tobacco consumption) and physical activity patterns were assessed.
Results: Prevalence of T2D was 22.9% (n=80) in urban and 9.9% (n=37) in rural settings. Urban T2D was significantly (<0.05) positively correlated with known obesity marks, lifestyle risk factors, systolic blood pressure, and age. In terms of BMI, urban respondents were more likely to

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be overweight ($p<0.001$) than their rural counterparts. As well, urban respondents ate more meals per day ($p<0.001$) and consumed more alcohol ($p<0.001$). Of note, the increase in urban prevalence related to age is significantly ($p<0.05$) more pronounced in males than females. In rural settings, increased FBS was significantly negatively correlated with age, and and significantly ($p<0.05$) positively correlated with obesity markers, with 46% being assessed by BMI as underweight. The activity levels, assessed by distances walked, had rural Maasai with significantly greater distances ($P<0.0001$).

Conclusion: The study demonstrated an increase in T2D for those Maasai adopting more sedentary urban life styles. As a result, it is important for health programs to recognize the impacts of lifestyle changes in contributing to increasing prevalence in non-communicable diseases such as T2D.

Keywords: Maasai; type 2 diabetes (T2D); rural to urban migration; T2D risk factors.

1. INTRODUCTION

Tanzania, like many other low and middle income countries, is experiencing mass migration of people from rural to urban areas in search of jobs and better livelihoods [1]. This dramatic change from the active rural to more sedentary urban lifestyles has contributed to an increased proportion of overweight and obese individuals predisposed to chronic and non-communicable diseases including Type 2 Diabetes (T2D) [2].

The prevalence of diabetes is rapidly increasing globally, and particularly in urban areas [3]. The regions with the highest potential increases are Asia and Africa, where diabetes rates exceed three times current rate [4,5]. Some reports suggest that epidemic levels among Australian and Canadian Aboriginal people [6], whose prevalence rates of T2D are among the highest in the world [7], are likely attributable to rapid cultural or lifestyle changes.

Tanzania is experiencing a significant rise in the burden of diabetes. In the 1980s, the prevalence of T2D was reported as 0.9% in the rural areas [8]. Within 20 years, the prevalence had risen to 1.3% in rural areas and 4.0% in urban populations [9]. The Tanzania Diabetes Association (TDA) estimates there are more than 400,000 Tanzanians living with diabetes, obesity, and experiencing higher level of mortality from chronic non-communicable diseases [10]. Type Two diabetes rates appear to be catalyzed by rapid cultural changes, aging populations, dietary changes, decreased physical activity, and other unhealthy lifestyle behaviors; most factors associated with urbanization, westernization, and globalization.

A Tanzanian population-based survey involving adults from an urban center (Dar-es-Salaam) and from a village in rural Kilimanjaro District showed higher prevalence of T2D in urban dwellers [11]. However, this study involved individuals from different ethnic tribes; hence, it did not intentionally consider tribal or ethnic specific risk factors. Accumulating evidence indicates a genetic component in the susceptibility to T2D which is traceable at race, ethnic, or family levels [12,13]. It is therefore important to study diabetes susceptibility within different ethnic tribes or families locally and globally.

This study considers a unique sub-set of traditional pastoralists located in the Ngorongoro Crater Authority (NCA) known as the Maasai. The NCA Maasai community is increasingly under strain as a result of loss of access to traditional resources, which challenges the continuity and sustainability of their pastoral lifestyle in Tanzania [14]. As the traditional pastoralist livelihood disappears, the Maasi and similar pastoralist groups are forced to adjust in order to secure social, economic, and health futures with many opting to move to nearby urban environments in search of alternative opportunities [15].

The susceptibility of Tanzanian Maasai to T2D is not well established but presents an intriguing investigation because of their distinct origin, unique culture, and lifestyle. Maasai are the only Nilo-Hamitic tribe in Tanzania [16]. They live a very active lifestyle involving cattle herding and survive on a protein rich, high fat content diet comprised of milk, meat, and blood with limited starch [17]. Despite the high fat intake, indicators such as body mass index, waist circumference, blood and lipids are reported in the literature to be favorable for the Maasai, due to their high levels of physical activity [18,19]. Their traditional pastoralist lifestyle seemingly makes them less prone to obesity and other environmental predisposing factors for non-communicable diseases.

However, the traditional Maasai diet is progressively declining, particularly in NCA, where this research was conducted. The Maasai economy in the NCA is in a serious state of decline, with fewer people able to support themselves with traditional pastoralism. Further complicating is the restriction on the Maasai community in NCA which prohibits cultivation of food crops in conservation areas, thereby contributing to food insecurity. Fenton, Hatfield & McIntyre's [20] observation regarding food insecurity in the Maasai community in NCA suggested that participants did not always have access to adequate, safe, and nutritious food necessary to meet basic nutritional requirements. This conjecture is supported by Århem [21], who stated that maize porridge is an increasingly important part of Maasai diet, with the majority of people consuming one to two meals per day comprised solely of porridge or ugali (a stiff local staple).

According to a number of authors [15,22], the Maasai community has begun migrating from rural to urban areas due to land reduction, drought, food insecurity, and in search of jobs and better livelihoods. This migration has forced them from their traditional active lifestyle to an urban sedentary lifestyle, which may predispose them to T2D. In lieu of five kilometer daily treks to pasture their livestock, many Maasai are now involved in trading tanzanite gemstones [23], security services [15], and tourism [24]. Additionally, the impact of this migration on cultural rituals and behaviors, such as food restrictions/taboos and tobacco/alcohol use, remain unexplored [25-27]. To date, the impact of urbanization on Maasai community with respect to the prevalence and risk factors for non-communicable disease, such as T2D, has not been studied in Tanzania. The goal of this study was to compare the T2D prevalence and risk factors between Maasai individuals living rural traditional lifestyles within NCA and those living urban lifestyles in Arusha Municipality.

2. METHODOLOGY

2.1 Setting

This cross-sectional study involved the target population of rural and urban Maasai aged 18 to 75 years living in NCA and Arusha municipality. NCA is an area inhabited predominately by the Maasai ethnic group and yielded access to a large potential catchment. Furthermore, Arusha Municipal was selected because many Maasai migrants from NCA live in this municipality. Rural participants were living in Olbalbal, Alalilay, and Misigiyo villages in the NCA. Urban participants were drawn from Arusha city center, Olasit Village, Kisonga, Mbauda, Makumira University, University of Arusha, and Usa River.

2.1.1 Rural location

The Ngorongoro Conservation Authority (NCA) in Tanzania is one of the world's most important conservation heritage sites. It is located within the conservation highland of north Tanzania and forms the part known as the Serengeti-Ngorongoro ecosystem [28]. It is a multiple land-use area where Maasai pastoralists co-exist with large migratory herbivores and associated carnivores [29]. NCA is located 190 km west of Arusha municipality between Lake Manyara and Serengeti National Park. Covering approximately 8,292 square km, NCA also encompasses the Cradle of Mankind and is a designated UNESCO World Heritage Site [22].

2.1.2 Urban location

Arusha Region, with a population of approximately 1.7 million, is located in the eastern corner of Tanzania. It lies below the equator between latitudes 2° – 6° and between longitudes 35° – 38° east. The region shares borders with Kenya to the north, Kilimanjaro and Tanga Regions to the east, Dodoma Region to the south, and Singida, Shinyanga, and Mara Regions to the west. Much of the present area of Arusha Region was traditional Maasai land, hence, the Maasai remain the dominant ethnic community in the region.

2.2 Design

The study uses a cross-sectional study design, which is amenable to our intention to consider conditions, exposures, and diseases at one point in time in a given population.

2.2.1 Ethical review

This study received ethical support and approval from the Nelson Mandela African Institute of Science and Technology and the National Medical Research Institute (NMRI) of Tanzania. Verbal consents (known as 'dole gumba') were obtained from all participants before administering the questionnaires or obtaining measurements.

2.2.2 Sampling

Sample size was determined on the basis of the estimated populations of each village and the Arusha Municipal catchment. Olbalbal and Alalilayi have approximately 12 000 inhabitants and Misigiyo another 8 000 for a total population of 30 000. The approximate population of newcomer Maasai in Arusha Municipal was informed by the local administrators and the Pastoral Council to be approximately 15 000 individuals. Based on a 95% confidence interval with a 5% margin of error and a response distribution of r, the sample size of rural participants was set at 380 and 375 for urban participants.

The study used a convenience sampling technique. The researchers spoke with key community leaders, who were requested to organize the community meeting in order to explain the purpose of the study and request consents to participate. Rural recruitment was achieved through community meetings at each site where the local leaders shared the purpose and process of the study. For the urban recruitment, local groups and leaders who are involved with the urban-based Maasai were able to provide information at local meetings and events in Arusha. The following inclusion criteria were used in the recruitment process:

1. Member of Maasai tribe (ethnic)
2. Over 18 years of age
3. No previous diagnosis of diabetes (any type)
4. Able to respond to the study instrument (either in writing, verbally or through a translator)
5. Able to provide voluntary consent to participate
6. Resident of one of the villages or Arusha Municipal continuously for the last 3 or more years

A total of 724 participants were included in the study; 374 rural participants (142 male; 232 female) and 350 urban participants (193 male; 157 female). The mean age was 39 years in the urban centers, and 41 years in rural settings.

2.3 Data Collection and Analysis

Data collection was conducted by trained research team members. All laboratory testing was conducted onsite or at the Endulen Hospital in NCA. The basic demographic, anthropometric, and open questions were informed by the literature on T2D, reflecting risk factors, and known trends. Each of the measurement strategies, instrumentation, and limitations are noted in the following sections.

2.3.1 Demographic information

Basic information on age, gender, and relevant family history was collected from each individual by a translator who spoke the local language of Ma'a.

2.3.2 Anthropometric measurements

Anthropometric measurements, including height, weight, waist and hip circumference, were measured. Height (in centimeters) and weight (in kilograms) were determined using a Stadiometer (Seca^{TM} 206, USA). Participants were measured in light clothing and without shoes. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. Waist and hip circumference were determined using a stretch resistant tape measure. The waist circumference was measured (in cm) at the midpoint between the lower margin of the last rib and the top of the iliac crest. The participants were requested to gently expire during the measurement. The hip circumference was measured (in cm) around the widest portion of the buttocks, with the tape parallel to the floor. The waist to hip ratio (WHR) was calculated as waist in centimeters divided by hip size in centimeters.

2.3.3 Questionnaire

Data on lifestyle were collected through self-reporting in interviews and questionnaires in the local language of Ma'a. These were administered by a native Ma'a speaker who was member of the research support team and a trained medical officer. Information related to physical activity, tobacco/cigarettes use, alcohol consumption, and dietary intake was collected at this time.

2.3.4 Determination of blood glucose level

The fasting blood sugar (FBS) and Oral Glucose Tolerance (OGT) testing was done using a glucometer (One Touch™ Ultra, Life Scan Inc., United States) according to manufacturer's instructions. In each case, the automated results of the blood glucose level were displayed and read after 5 to 40 second. Of note, FBS was measured between 0700 h and 1100 h after a minimum 10 hours overnight fast. To determine the Oral Glucose Tolerance (OGT), 75 g of glucose was dissolved in 300 mLs of water and given to respondent to drink within 5 minutes after a taking FBS reading. After a two hour lapse, the glucose test was performed again. A laboratory technician was recruited to assist in taking blood samples from study participants. The diagnostic criterion for T2D was fasting venous whole blood glucose less than 6.1 mmol/L. The criterion for Impaired Glucose Tolerance (IGT) was FBS greater than 6.1 mmol/L and 2-hours post glucose load greater or equal to 7.8 mmol/L to less than or equal 11.1 mm/L, in accordance with the WHO recommendations (1999). A limitation in this study component was the lack of determination whether individual participants had taken a normal diet three days prior to testing.

2.3.5 Determination of serum total cholesterol

For cholesterol levels, approximately 3 mLs of blood were drawn from each participant by a trained laboratory clinician. This sample was transported on the same day to the Endulen Hospital for analysis of total cholesterol. The blood collected was first centrifuged to obtain serum, and a calibrated automated analyzer (BA88A Semi-auto Chemistry Analyzer™, Mindray Medical International Ltd., India) was used to determine cholesterol levels. About 1000 micro liters of water for injection was run first into machine (i.e., water blank) followed by 1000 micro litres of reagent (i.e., reagent blank). Finally, a prepared mixture comprised of a10 micro litre of sample (i.e., serum with 1000 micro litre of reagent and incubated at 37℃ for 5 minutes) was processed and tested in the unit. The results were automatically displayed and recorded. In this study, the following categories for cholesterol levels were utilized: LOW<3.9 mmol/L; NORMAL 3.9-5.72 mmol/L; and HIGH ≥ 5.72.

2.3.6 Determination of blood pressure

An automated machine (Omron™ M4) was used for blood pressure (BP) measurements. The BP was measured on the participant's right arm while in a seated position, using an automatic blood pressure cuff. Before taking the BP measurements, the participants were allowed 5 minutes rest. Two measurements were taken within a two hour interval. The two readings were averaged, reported, and used in the analysis.

2.3.7 Data analysis

Data was entered, coded, cleaned, and analyzed by using GraphPad Prism™ software (Version 6). The Chi-square test was used to compare prevalence of T2D between rural and urban populations. Pearson's correlation and Linear Regression were used to determine the degree of linear dependence between selected variables with p-value less than 0.05 considered as significant.

3. RESULTS AND DISCUSSION

3.1 Prevalence of T2D in Rural and Urban Maasai

The overall prevalence of T2D in the urban and rural Maasai sample was 16.2% (n=117). The prevalence of T2D in urban residents (22.9%, n=80) was significantly higher ($p<0.0001$) than for rural residents (9.9%; n=37).

The variable of age yielded opposite influences on propensity for T2D between rural and urban Maasai. In the urban Maasai participants, T2D prevalence increased with increasing age and was highest at 60 years and above ($p<0.0001$) whereas in rural Maasai participants the prevalence decreased with increasing age and was lowest at age 60 years and above (Fig. 1). The increase in T2D with age in urban residents was more pronounced in males than in females ($p< 0.05$) (Fig. 2a). In rural Maasai, the change in T2D with age was similar across gender (Fig. 2b).

3.2 Fasting Blood Sugar Correlates and Regression of Urban Maasai

The urban FBS was positively correlated with the obesity markers including BMI, weight, waist-circumference, hip circumference, and WHR (Table 1). Fasting blood sugar was also significantly correlated with other known T2D risk factors including age, blood pressure, and total cholesterol.

3.3 Fasting Blood Sugar Correlates and Regression of Rural Maasai

Fasting blood sugar in rural Maasai was positively correlated with the obesity markers: BMI, weight, hip circumference, and waist circumference (Table 2); and negatively correlated with age.

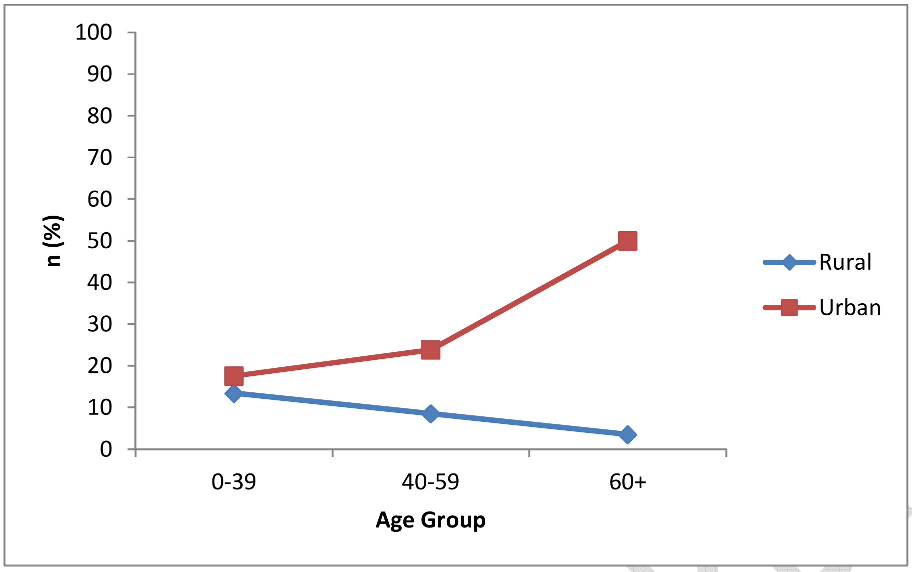

Fig. 1. Prevalence of T2D by age group in rural and urban Maasai

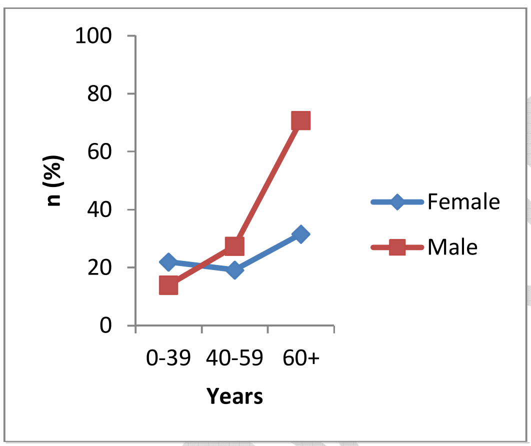

Fig. 2a. Prevalence of T2D by age and gender age in urban Maasai

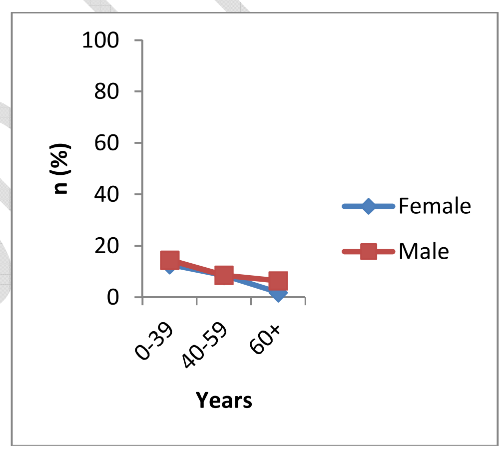

Fig. 2b. Prevalence of T2D by and gender in rural Maasai

Table 1. Pearson correlation and linear regression analysis for fasting blood sugar in urban Maasai participants

Risk factor	Pearson correlation		Linear regression	
	Correlation Coefficient (R)	P	R^2	Line equation
Age	0.277	< 0.0001	0.007651	Y = 2.451*X+25.84
Waist circumference	0.2441	< 0.0001	0.05957	Y= 1.489*X+73.45
Weight	0.3214	< 0.0001	0.1033	Y = 2.344*X+51.77
Body mass index	0.3803	< 0.0001	0.1446	Y= 0.8626*X+16.58
Waist to hip ratio	0.1547	0.0037	0.02393	Y = 0.005584*X+0.8391
Hip circumference	0.1678	0.0016	0.02815	Y = 1.057*X+88.13
Systolic BP	0.1974	0.0002	0.03896	Y = 2.777*X+113.9
Diastolic BP	0.8196	0.0011	0.01633	Y = 0.9042*X+78.82
Total cholesterol	0.1704	0.0014	0.02904	Y = 0.09265*X+2.162

3.4 Differences in T2D Risk Factors between Urban and Rural Maasai

3.4.1 Body Mass Index (BMI) among urban and rural Maasai

A significantly higher proportion ($p<0.0001$) of rural respondents (46%) had BMI within the "underweight" category as compared to only 21% in urban residents falling into this category (Fig. 3). The opposite was true for the 'overweight' category in which urban respondents were significantly ($p<0.001$) more likely to be overweight. The cut-off points adopted for this study were: UNDERWEIGHT<18.5 kg/m2; NORMAL 18.5-24.9 kg/m2; OVERWEIGHT 25-29.9 kg/m2; and OBESE ≥30 kg/m2.

3.4.2 Waist to hip ratio

Nearly two-thirds of Maasai respondents (rural [63%] and urban [69%]) had WHR falling within the normal category and the rest 31-37% fell within the high category. There was no significant difference between rural and urban residents for WHR.

3.4.3 Distances walked by the urban and rural Maasai

Differences in physical activity as determined by daily distance walked were noted between rural and urban residents. Significantly more rural Maasai walked longer distances (i.e., walked 5 km or more) ($p<0.0001$) while urban residents significantly walked shorter distances (i.e., less than 5 km) ($p<0.001$).

Table 2. Pearson correlation and linear regression analysis for fasting blood sugar in rural Maasai participants

Risk factor	Pearson correlation		Linear regression	
	Correlation coefficient (R)	p	R^2	Line equation
BMI	0.2021	< 0.0001	0.04097	Y = 0.7858*X+15.34
Weight	0.2441	0.0009	0.02916	Y = 2.368*X+44.26
Hips	0.1596	0.002	0.02546	Y = 1.583*X+80.53
Waist	0.1115	0.031	0.01243	Y = 1.251*X+68.42
Age	-0.1041	0.0443	0.01083	Y = -2.051*X+53.86

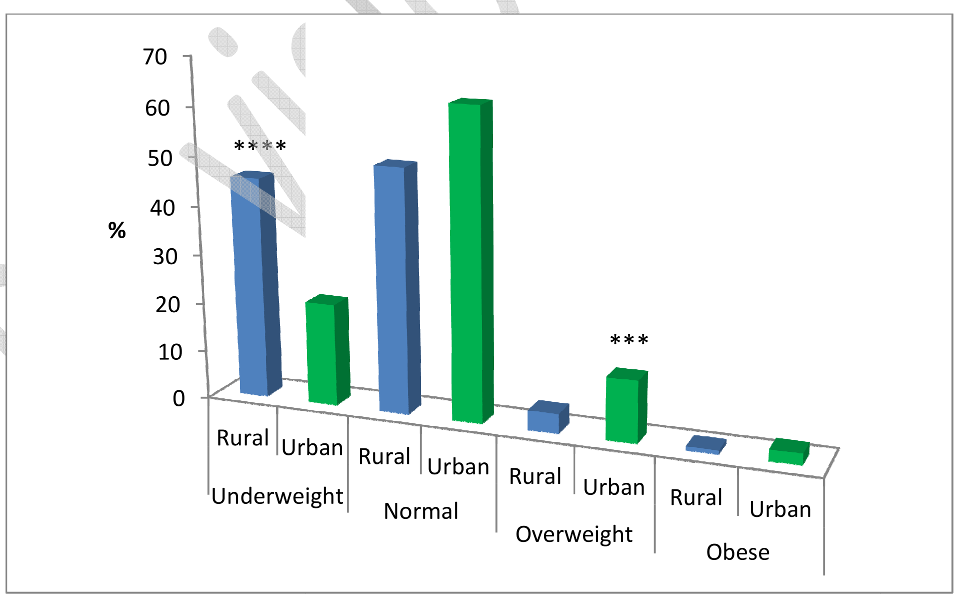

Fig. 3. BMI profiles of the rural and urban Maasai by categories (n=724)
*[*** p<0.001 *****p<0.0001]*

3.5 Differences in Total Cholesterol between Urban and Rural Maasai

More than 90% of rural and urban respondents had total cholesterol falling within the "low" category and the remainder was within the normal and high categories. There was no significant difference in total cholesterol between rural and urban respondents.

3.5.1 Number of meals consumed by urban and rural Maasai

Difference in number of meals taken daily was observed between rural and urban respondents. Significantly more rural respondents took fewer meals (i.e., 1-2) ($p<0.0001$) while significantly ($p<0.001$) more urban respondents took more number of meals (3-4) (Fig. 4).

3.5.2 Alcohol consumption and tobacco use between urban and rural Maasai

There was contrasting preference for alcohol and tobacco between urban and rural respondents. While significantly more urban respondents took alcohol ($p<0.001$), the use of tobacco was significantly higher in the rural population ($p<0.01$).

4. DISCUSSION

Tanzania, like most developing countries, is experiencing a wave of migration from rural to urban centers in search of better life, amongst other reasons. While the change from rural to urban lifestyle may have some benefits in terms of better education, health and more income, it predisposes individuals to chronic diseases including T2D [30]. In Tanzania, migration from rural to urban centers has involved almost all the 230 ethnic tribes [31]. The Maasai ethnic group, however, was the least likely to join the urban migration trend because of their strong affinity to their traditional lifestyle. Maasai in rural settings have a unique way of dressing, a very active life based on pastoralism involving migration from place to place in search of pastures for their livestock, and depend entirely on protein- based food comprising of milk, meat, and blood tapped from their animals. Often lifestyle and habits, as suggested before, are credited with their apparent resilience to select chronic diseases [18]. The current urban migration trend has not spared the Maasai, as they are now found in most urban centers, and are adjusting to an urban lifefstyle.

This study compared the T2D in Maasai living traditional life style in Ngorongoro and those living in Arusha urban in terms of prevalence of T2D and the various pre-established risk factors for T2D. In this study we observed higher prevalence of T2D in urban compared with rural populations. This finding is consistent with similar studies on rural urban differences on T2D in Tanzania [11] and other developing countries [32], but differ from than other studies [9,33]. The disparity may be explained by differences in the population studied, age profile, or the cut-off criteria used to identify T2D patients. Additionally, the simple cross-sectional nature of this study may contribute to the differences.

We observed a significant correlation between blood glucose and obesity (BMI and WHR), age, blood pressure, weight, waist circumference, total cholesterol, and hip size. The urban Maasai FBS was positively correlated with age, which is consistent with observations elsewhere [34]. However, the change was more pronounced in males than females; by age 60 years and above, the prevalence was 2.3-fold in favor of males. The possible explanation for this difference is not yet clear but may be genetically determined (sex) or environmentally determined. For example, urban males will have more disposable income and liberty and may become involved in high risk behaviors such as consumption of alcohol and eating higher calorie meals out of home.

In contrast to urban T2D, age was negatively correlated with rural T2D, which was unexpected finding based on current literature [35]. In contrast to urban T2D, there was no gender difference in age-dependent changes in the prevalence for rural Maasai. In both males and females, the T2D prevalence in rural Maasai decreased with increasing age and was lowest in the age group of 60 years and above. Although the exact mechanism remains unclear, the current results suggest that sex or age is not an independent risk for T2D. It is possible that the two factors are dependent on other risk factors such as obesity or hypertension, amongst others, in the absence of which their impact diminishes. Some of the factors that may have negatively influenced the impact of sex or age may be revealed by lifestyle and/or the anthropometric values for rural Maasai. Close to half of rural Maasai were underweight (70% with low waist-to-hip ratio), consumed less number of meals, but had more physical activity than their urban counterparts. This active low risk profile,

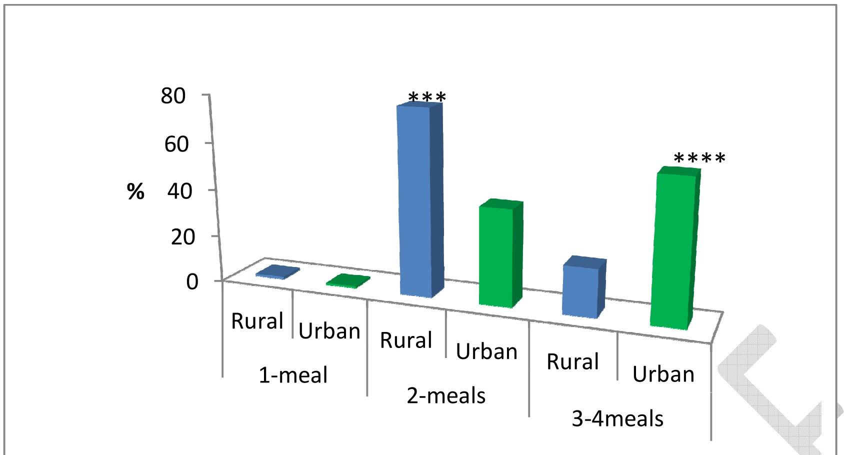

Fig. 4. Number of daily meals eaten by the rural and urban Maasai (n=724)
*[****p<0.0001, ***p<0.001]*

amongst other factors, could possibly negate the impact of age or sex on T2D. This unique pattern of rural T2D approximates what was reported for the hunter gatherer tribes before the advent of urbanization in Africa [36].

Blood glucose levels in urban Maasai was significantly positively correlated with increased blood pressure; a finding consistent with existing literature. People with T2D experience reduction of nitric oxide in endothelial cells in blood vessels damaged by molecules called free radicals [37]. This damage leads to endothelial dysfunction as demonstrated by loss of blood vessel elasticity which leads to increase in blood pressure. Surprisingly, rural Maasai FBS was not correlated with high blood pressure as for urban Maasai. Although no clear explanation is known, it is possible that the impact of hypertension on blood glucose levels is also dependent on presence of other factors such as obesity [38].

The rural blood glucose pattern and nutritional status observed for the Maasai living in NCA may not be representative of all rural Maasai in Tanzania or elsewhere. Maasai living in NCA face higher food shortage risks compared to their counterparts elsewhere. Due to shortage of land and reduced number of livestock, the rural Maasai are no longer entirely dependent on milk, meat, and blood for survival. Their food is now supplemented with grains and other types of food. As a result, rural Maasai have started cultivating maize and other food stuff to supplement their traditional diet. However, Maasai living in NCA do not have such an option as they are not allowed to cultivate crops or vegetables around their homes lest they interfere with conservation efforts. Overall, the NCA Maasai are exposed to a situation where they do not have enough to eat and lack access to vegetables and fruits which may improve their nutritional status. Therefore, while the current lifestyle puts them at low risk for T2D and possibly other chronic non-communicable diseases, it may on the other end render them susceptible to infectious diseases.

Despite significant differences in prevalence of obesity and T2D between rural and urban Maasai, the cholesterol profile was not significantly different. This finding indicates that lifestyle change has little effect on the cholesterol profile. Our results concur with previous findings that Maasai have genetic mechanisms for reducing cholesterol which compensates for the large amounts of cholesterol they consume from milk [39].

The major risk factor for chronic diseases, such as T2D, includes obesity which can be expressed by the two anthropometric markers - weight-to-height ratio (BMI) and waist-to-hip ratio. In our study, BMI was significantly positively correlated with FBS both in urban and rural population consistent with observation elsewhere [40]. In contrast to BMI, the WHR ratio was correlated with blood glucose only in urban but not rural residents. It is therefore advisable to use both the BMI and WHR ratio when conducting these types of studies as there appears to be variability within populations with respect to anthropometric measurement. Furthermore, waist circumference (R=0.24) or hip size (R=0.17) alone were relatively more correlated to urban FBS as compared to WHR (R=0.15). This finding aligns with those of a previous study which indicated that depending on where fat is stored, the WHR may not be the ideal indicator of obesity; and, in lieu, one should consider the composite parameters (i.e., waist or hip size) [41].

5. CONCLUSION

In conclusion, the present study investigated whether change from rural to urban life style for Maasai would have an impact on the prevalence of T2D. Results demonstrated the increase in T2D for Maasai living in urban, similar to reports by other studies in Tanzania and the rest of the world. Obesity, age, and systolic blood pressure were the major correlates for urban T2D. Therefore, targeted programs to address this luring and lifestyle changing environments must be considered by health programmers in order to avert epidemic levels of non-communicable diseases such as T2D in these urban migrants.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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