

## ORIGINAL ARTICLES

# Forecasting chronic diseases in Africans – Evidence from an immigrant population cohort experience

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## ABSTRACT

**Background:** Many African countries have seen a decline in communicable diseases and infant mortality with a concomitant emergence of Western-type, resource-draining, chronic diseases in a growing mid-aged population. This poses a threat to countries with very limited resources and points to the urgent need for data to predict the impact of this emerging trend on health and economy.

**Methods:** A cohort of 76,356 unselected immigrants to Israel, from the Gondar area in Ethiopia, was studied for patterns of non-communicable diseases emergence following their move to a Western environment. Age-specific prevalence rates of cardiovascular disease, cancer, and important risk factors (hypertension, diabetes, hyperlipidemia, BMI and smoking) were calculated by time since immigration and compared to those of 767,082 same period immigrants from the Former Soviet Union (FSU) and to the Israeli Jewish population, using the Clalit Chronic Disease Registry.

**Results:** Prevalence rates of diabetes, hypertension, hyperlipidemia, obesity and smoking all increased significantly in every age-group among the Ethiopian immigrants. The increase started within 5 years of immigration and sometimes exceeded the rate in the local Israeli population, most notably with diabetes. Disease rates among the FSU immigrants were lower in magnitude and different in trend. Rates of malignancies changed differentially by type and etiology of disease.

**Conclusion:** Major temporal increases of chronic diseases morbidity were documented in immigrants from semi-rural Ethiopia to a Western environment. African countries undergoing gradual Westernization need to take immediate preventive measures to tackle the emerging problem. These can involve health education measures or the use of risk reducing drugs as possible approaches.

**Key Words:** Non-communicable diseases, Africa, Immigration, Prevalence, Israel, Diabetes, Hypertension, Hyperlipidemia, Obesity smoking

## 1. INTRODUCTION

Communicable and infectious diseases are the leading causes of morbidity and mortality in sub-Saharan African countries.<sup>[1-3]</sup> The burden of communicable diseases has sig-

nificantly limited life expectancy and slowed the growth and development of these countries.<sup>[2]</sup> A steep age pyramid with many young children reflecting high fertility, but few young adults, who are the major engine for progress,

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reflecting high childhood mortality, is common to developing countries.<sup>[4,5]</sup> Improvements in hygiene, water supply, nutrition and treatment<sup>[6,7]</sup> have resulted in declining infant mortality and childhood morbidity from communicable diseases<sup>[8-10]</sup> while non-communicable diseases(NCD) , common to Western countries, have increased in the mid-aged population.<sup>[11-16]</sup> NCDs are predicted to have a major impact on the health profile of African countries gradually undergoing westernization. The high cost of treating cardiovascular and malignant diseases poses a great threat to the future health and economics of Africans.<sup>[17]</sup>

The immigration of a whole, semi-rural, sub-Saharan African population from the Gondar region in the Amhara district of Northern Ethiopia (an area with per-capita GDP \$619 in 2015)<sup>[18]</sup> to Israel (per-capita GDP \$35,729),<sup>[18]</sup> provided a unique opportunity to study the patterns of disease development in an unselected immigrant population. The observed dynamics in health and disease in this population can aid policy makers in predicting disease patterns in sub-Saharan African countries in the post communicable diseases era.

The aim of this study is to examine the effects of Westernization on the development of chronic diseases and condition in an Ethiopian immigrant population to Israel.

## 2. METHODS

### 2.1 Study design

This is a prospective historical cohort study, where a dynamic cohort of immigrants from Ethiopia was followed-up over

several decades. The development of chronic diseases or disease risk factors over time was compared to that in a second cohort of immigrants from the Former Soviet Union (FSU).

### 2.2 Study population

All Ethiopian-born members of Clalit Health Services (CHS), the largest not-for-profit health provider in Israel, covering more than 50% of the Israeli population, were identified. Clalit Health Services provides primary to tertiary care in its facilities which are of high western standard. The medical service content is according to the non-discriminatory Israeli Health Act Law which guarantees full free-of-charge coverage and full access to all residents of Israel. All providers within the Clalit system are computerized and all clinics use the same software platform. CHS maintains a high-quality prevalence registry of over 200 chronic diseases and risk factors based on data from primary-, secondary- and tertiary-care medical records, prescription records, and laboratory tests. This registry has been validated and common disease rates are comparable to those reported in other Western countries.<sup>[19,20]</sup>

Ethiopian immigrants arrived in Israel in two large waves; 10,690 in 1984 (Operation Moses) and 24,414 in 1991 (Operation Solomon). Another 40,000 Ethiopians immigrated to Israel since then for a total study cohort of 76,345 people (see Table 1). The vast majority of immigrants from Ethiopia are CHS insurees.

**Table 1.** Distribution of study cohorts by year of immigration, country of origin and age-group, Israel

Year of Immigration/ Age at immigration	1984-1988	1989-1991	1992-2000	2001-2005	2006-2015	Total
<b>Origin: Ethiopia</b>						
0-19	7,223	13,083	6,331	7,275	8,763	42,675 (55.9%)
20-29	2,186	2,237	1,904	1,882	3,238	11,447 (15.0%)
30-39	1,367	1,931	1,312	1,363	2,478	8,451 (11.1%)
40-49	745	1,592	696	856	1,178	5,067 (6.6%)
50-59	557	1,266	492	650	660	3,625 (4.7%)
60-69	780	1,362	403	490	435	3,470 (4.5%)
70+	228	541	248	348	245	1,610 (2.1%)
Total	13,086	22,012	11,386	12,864	16,997	76,345
<b>Origin: FSU</b>						
40-49		42,411	65,217	9,398	3,709	120,735 (12.4%)
50-59		32,911	53,385	8,379	3,456	98,131 (10.1%)
60-69		34,935	58,118	7,601	4,077	104,731 (10.7%)
70+		19,261	39,476	4,163	2,593	65,493 (6.7%)
Total (all ages)		332,863	531,389	75,141	35,668	975,061
<b>Veteran Israeli Jews (2015)</b>						
40-49						302,267 (9.6%)
50-59						316,532 (10.0%)
60-69						337,583 (10.7%)
70+						360,692 (11.4%)
Total (all ages)						3,155,324

Another population, used for comparison, is that of over a million persons from the (FSU) who immigrated to Israel during the 1980's-90's (see Table 1).

### 2.3 Study variables

The prevalence of the following health-related conditions (diseases or risk markers) was studied: hypertension, Diabetes Mellitus, hyperlipidemia, smoking, obesity (BMI weight/height<sup>2</sup>) and malignancies. The definition of the abovementioned disease states or risk factors in the chronic diseases register of CHS is based on multiple clinical data sources and the final call was made according to standards set by Western professional organizations.

Analyses of chronic diseases were confined to immigrants who were alive in 2015 and over the age of 40; analysis of smoking behavior included all age groups. It is of note that the proportion of the population over age 40 among Ethiopian immigrants was only 17.9%, compared to 39.9% among FSU immigrants and 41.7% in the general Israeli Jewish population (see Table 1).

### 2.4 Statistical analysis

Prevalence of diseases in 2015 was calculated by age in 2015 and length of time in Israel for the Ethiopian and FSU immigrants, and compared to the overall age-specific background prevalence rate in 2015 for Israeli Jews in our registry. Trends over time within each age group were analyzed using the linear by linear chi-square statistic. Relative risks and 95% CI were calculated for each disease, age group and time in Israel. Pearson's Chi square was used to compare the disease rates of the immigrants with the rates in the local Jewish population. A *p*-value < .05 was considered statistically significance. Data were analyzed using IBM SPSS Statistics, Version 24.

## 3. RESULTS

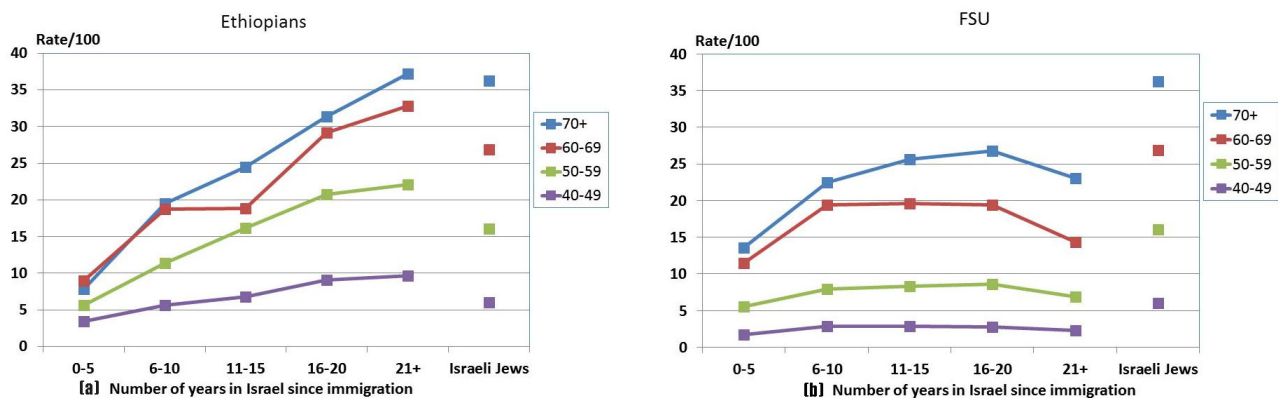
Major differences between study groups in disease rates and their dynamics were identified.

Table 1 presents the distribution of age at immigration and year of immigration for our 3 study cohorts – Ethiopians (n = 76,345), FSU (n = 975,061) and the general Israeli Jewish population (n = 3,155,324).

The age-pyramid of the Ethiopian immigrant cohort to Israel is very similar to the age distribution reported in Ethiopia for 2010, with less than 20% of the population over age 40.<sup>[21]</sup>

Prevalence rates of all conditions rose steeply with increasing time in Israel, overall and in each age-specific stratum.

Diabetes, low at immigration among Ethiopians, increased by 250%-400% over time from immigration in all age groups (age in 2015), similarly in males and females. After 20 years in Israel the prevalence rate of diabetes in every age-group among the Ethiopians is higher than in Israeli Jews (see Figure 1a). Young mid-age people (age 40-49 in 2015) showed an immediate increased risk from RR=1.5 5 years post-immigration to RR = 4.2 after 20 years compared to the 60-69 year olds who had an RR=1.1 and 1.95 after 10 and 20 years respectively, and the 70+ year olds with RR=1.22 and RR=1.44 only after 15 and 20 years respectively. All risk estimates in all age groups and for most immigration periods were statistically significant and the *p*-for-trends were highly significant (< .0001) (point estimates shown in Appendix). Immigrants from the FSU showed a pattern of mildly increased rates of diabetes of 10%-25% in years 5-10 after immigration followed by a plateau, and a decline in rates after 20 years to rates comparable to or lower than the baseline rates of Israeli Jews (see Figure 1b).



**Figure 1.** Diabetes Mellitus Prevalence in 2015 by number of years in Israel since immigration and age in 2015

Similarly, rates of hypertension, which were generally low at time of immigration compared to local rates, increased by 250%-300% in Ethiopian, but not in FSU, immigrants in

every age-group(see Figures 2a, 2b). After 16+ years from immigration the relative rate among the Ethiopians age 40-49 was 3.3-3.8 times higher than in Israeli Jews, ages 50-59 was

1.6-2.3 times higher and in the 60-69 year olds was 1.3-1.4 times higher. This is compared to much lower corresponding RRs of 1.6, 1.3, 1.1 among the immigrants from the FSU. Here again much of the change was noted among the younger

age groups who reached higher disease rates and reached them earlier after immigration. (Point estimates shown in the Appendix)

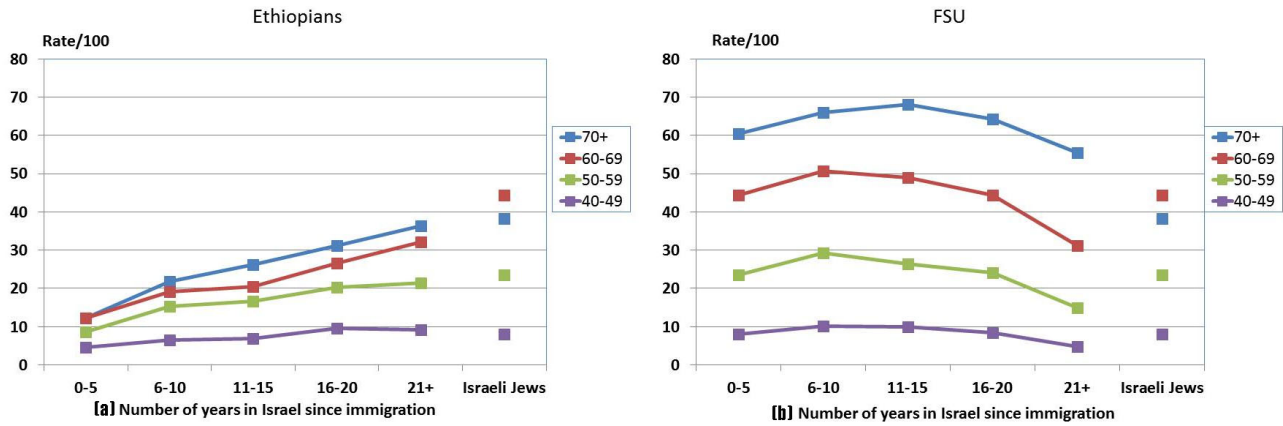


Figure 2. Hypertension Prevalence in 2015 by number of years in Israel since immigration and age in 2015

Hyperlipidemia rates among the Ethiopians were very low upon arrival in Israel among older immigrants and have almost doubled within 20 years, to reach the rates found in Israeli Jews. Mid-aged immigrants arrived in Israel with age-specific hyperlipidemia prevalence rate similar to local rates

but have increased significantly within 20 years to about double the local rates (see Figure 3a). Rates in immigrants from the FSU were somewhat higher than local rates upon arrival and declined significantly after 20 years from immigration to the local rates (see Figure 3b).

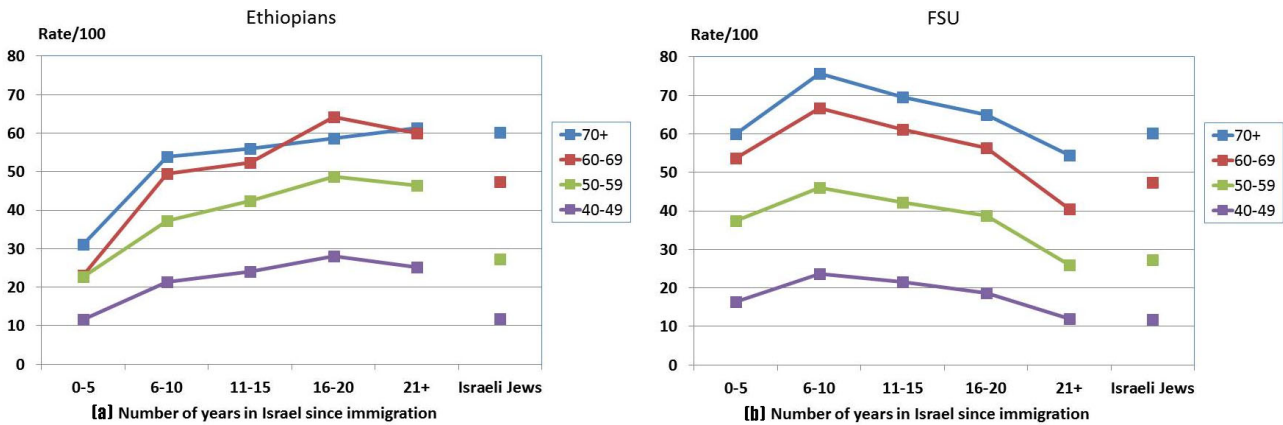
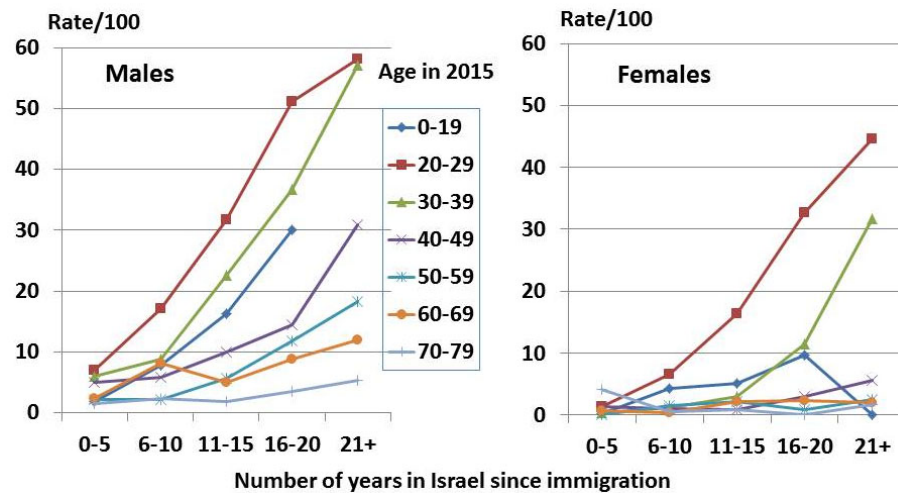


Figure 3. Hyperlipidemia Prevalence in 2015 by number of years in Israel since immigration and age in 2015

The Body Mass Index (BMI) of the Ethiopian immigrants was extremely low at time of immigration but rose from 16% overweight (BMI > 25) to 37% within less than a decade. The rate of obesity as defined in western countries (BMI ≥ 30) is still very low among the immigrants but did increase threefold.

tobacco smoking rates that are almost double the rates of the general Israeli Jewish population. The rates among women who immigrated as children and who were between ages 20-29 in 2015 are currently 32% (15 years after immigration) and 45% (20 years after immigration), compared to about 20% among young Israeli women. Similarly smoking rates increased to almost 60% 20 years after immigration among men who immigrated as children or teenagers, compared to 36% in the veteran population<sup>[22]</sup> (see Figure 4).

Smoking, which was practically non-existent among the Ethiopians upon immigration, quickly became popular among the young men and women, with current self-reported



**Figure 4.** Smoking rates among Ethiopian immigrants by gender, number of years in Israel since immigration and age in 2015

### Malignant diseases

Two groups of malignancies are identified in our cohorts, those with an infectious agent etiology (usually HPV, HBV, EBV, CMV) and those common in the Western world (breast cancer, colorectal cancer, prostate cancer, lung cancer). Ethiopian immigrants demonstrate higher prevalence rates of virus-driven malignancies of the cervix and liver and much lower prevalence rates of breast, colon-rectum, prostate and lung cancers leading in Western countries.

## 4. DISCUSSION

Major increase in prevalence rates of chronic diseases and their risk factors which are common in Western populations, were identified in this extensive analysis of the long-term experience of a large, unselected, total population which emigrated from semi-rural sub-Saharan Africa (Northern Ethiopia) to a Western country (Israel). This immigration event can be viewed as a large human natural experiment and can shed light on the dynamics of disease development and acquisition of unfavorable health habits upon exposure to a Western culture. These detailed time-trend and magnitude data can serve both health-care planners of immigration absorbing countries, as well as those of the countries of origin in Africa in preparing for the future. The latter is of importance due to dramatic social changes in the African countries, experiencing different degrees of Westernization<sup>[16,23,24]</sup> taking into account the fact that the more gradual transition of local African countries into westernized life style in Africa might yield a somewhat slower process of disease development. It is hard to point at one change in behavior or risk factor as the sole responsible for the change in health status. Yet, it seems that diabetes was the first disease to increase and demonstrated the steepest increase.

One strength of our study is that we have an unselected population. Immigration is usually an act of either the selected best, those who are skilled or driven to have a better life in another country, or of the deprived who flee a disaster area and become refugees. Neither group is representative of the health conditions of their population of origin. This is not the case with the current Ethiopian immigration where an entire community moved to fulfill a long held religious belief. These data are unique in that they represent what can be viewed as a natural experiment when a whole, unselected, population moves from an underdeveloped area of the world to a modern country.

Another strength is that Israel is a country with much experience in absorbing immigrant populations. The immigrants arrived to a country with a health-for-all policy and therefore were granted full health service with full access immediately upon arrival. While having the very unique advantage of being able to follow-up a total and unselected population of immigrants, our data could be distorted if the use of health services (from both the user and the provider angles) differs between the immigrant and veteran populations due to discrimination, lack of language and communication tools or other socio-economic and cultural barriers typical to immigrant populations.

Our study shows major changes in prevalence rates of chronic diseases in every age group and with increasing years since Westernization (immigration). These immigrants arrived in Israel with very little history of chronic diseases; however a major increase in prevalence rates of common conditions such as diabetes, hypertension, hyperlipidemia, obesity and smoking was seen in this population. An increase in diagnoses was seen across all age groups but for some diseases

started soon after immigration and for all diseases peaked after 20 and more years in Israel. The most adverse effects were seen among those who immigrated at younger ages. The comparison with immigrants from the Former Soviet Union (a more westernized country) emphasized the findings by both, showing much higher rates of disease at immigration than that seen in the Ethiopians, and showing much milder increases in disease rates. Other studies emphasized the fact that these changes occurred while maintaining desirable BMI levels.<sup>[25,26]</sup>

Suggestions of increase in chronic diseases and obesity, led by diabetes, have already been reported in small observational studies in sub-Saharan Africa.<sup>[2,13,15,27]</sup> Studies reported in Israel in early years of the immigration waves demonstrated the lack of chronic diseases such as diabetes, hypertension or hyperlipidemia<sup>[28-30]</sup> and very low BMI among the immigrants.<sup>[31]</sup> The Israeli Cancer Registry reported low rates of most tumors and lack of common malignancies such as lung cancer.<sup>[32]</sup> Overall, cancer has not been shown to change patterns dramatically following immigration in spite of change in risk-exposures such as smoking, possibly because the increase in smoking was seen mostly in the young who have not yet reached enough years of residence to express tumors. On the time axis, diabetes was the first to appear<sup>[31-33]</sup> and malignancies were the last and of the smallest magnitude, reflecting the nature of the disease processes involved and their vulnerability to Western behavioral and environmental exposures. Diabetes has previously been demonstrated to appear early after cultural change in Israel and in several other studies in different populations of the world.<sup>[34,35]</sup> Diabetes experts suggest that in this population the fasting insulin levels and insulin response to glucose load was low, corresponding with high threshold for insulin secretion and an insulin resistance associated with glucose intolerance.<sup>[33,34,36]</sup> The Thrifty genotype model and maternal malnutrition were suggested to explain the fast emergence of diabetes in this population.<sup>[35]</sup> It has also been suggested that the Ethiopian immigrants had an increase in certain HLA class II haplotypes and that this immunogenetic predisposition when encountering a diabetogenic environment leads to increase in overt diabetes.<sup>[37]</sup>

Hypertension was reported to increase early after immigration, but hyperlipidemia was slow to increase.<sup>[30]</sup> The dramatic change in disease rates may be attributed to change in environmental, behavioral, social and cultural exposures,<sup>[24,38]</sup> also documented among the Ethiopian immigrants to Israel.<sup>[39]</sup> The differing rates of change of the specific diseases reflect the varying role of the environmental exposures and their interaction with the biology of the exposed population.

Can we then generalize from our findings and forecast the rate and magnitude of development of chronic diseases in the already Westernizing Africa? Generalizability can be influenced by differences between the immigrant Ethiopian population and the general African or even other Ethiopian populations, and by the similarity in the dynamics of Westernization that our immigrant population experienced compared to the local African population in terms of the speed of transition. While Africa, or even Central Africa cannot be viewed as one demographic or economic entity, our immigrant population lived in the mountainous area of North-West Ethiopia, mostly the Gondar region, which combines a rural area with classical small cities, and therefore is as close as possible to representing an African semi-rural population in terms of lifestyle, economic capacity, infectious diseases exposure and access to health services. The Ethiopian immigrants to Israel were also similar to the local inhabitants of Ethiopia in their thin body build and life style (no smoking, similar diet, high physical activity). Body built could be a critical element in the risk of developing chronic diseases and especially diabetes in the immigrants who are exposed to a major change in diet, mostly reflected by increased carbohydrates, and the lower need for physical activity (lower need for long walks to work). The immigration process described here, however, involved an abrupt uprooting and differs from the gradual transition of a local population to the effects of Westernization. Many Ethiopian immigrants to Israel continued residing in absorption centers as whole communities, sometimes for many years, and thus for some the assimilation process was somewhat gradual and many local dietary habits were kept resulting in different diseases developing at different speeds. The younger immigrants presumably assimilated faster which is reflected in the earlier and higher rates of diseases. It can thus be predicted that even if the magnitude of change among the immigrants is somewhat overstated, it reflects a long process of change that is likely to be experienced by similar populations undergoing slower, yet similar, exposure to a more Western lifestyle. The FSU immigrants who served as a comparison group arrived in Israel from conditions more similar to those of Israel (\$11,000 GDP PP), yet had a significantly less developed health system than in Israel. The immigration from the FSU differed as it was usually selective, and of somewhat weaker parts of the source population. This corresponds to the study findings where the immigrants from the FSU showed trends which were quite different from the Ethiopian immigrants and less different than those of the veteran Israeli population.

In conclusion, based on the results of the unique opportunity to study this sub-Saharan African cohort which immigrated to a Western country, we predict a major change in NCDs

rates in similar African or other non-westernized populations as result of the growing exposure to Western influences. Different diseases are expected to develop at different speeds, and will potentially peak at rates higher than those experienced by Western communities. This forecast, if valid, predicts a heavy societal and financial load on the African society. Due to the extremely high costs of diagnosing and treating most NCDs, strategic plans based on primary prevention are probably the most logical approach, both medically and economically. Given the limited documented success of introducing health behavior changes in large populations, an approach which involves risk-reducing medications (chemoprevention) is worth investigating for this target population. An approach using medications such as aspirin, statins, and metformin has been suggested before for Western populations,<sup>[40,41]</sup> and could be of special benefit to populations that are only starting to develop classical western chronic diseases.<sup>[42]</sup>

## AUTHORS' CONTRIBUTIONS

Gad Rennert: Study initiation, literature search, study design, data analysis, data interpretation, writing the manuscript.

Hedy S Rennert: Study design, data collection, data analysis, data interpretation, writing the manuscript.

Walid Saliba: Literature search, study design, data interpretation, critical review of the manuscript.

Adane Kebede: Background information provision, data interpretation, critical review of the manuscript.

Sisay Yifru: data interpretation, critical review of the manuscript.

Liat V Rennert: Study initiation, background information provision, data interpretation, critical review of the manuscript.

Abebaw Gebeyehu: Background information provision, data interpretation, critical review of the manuscript.

## CONFLICTS OF INTEREST DISCLOSURE

The authors declare that they have no competing interests.

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