Cardiovascular health in urban Suriname

The Healthy Life in Suriname (HELISUR) study

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The general aim of this thesis was to expand the evidence on cardiovascular health and related risk factors in the urban middle-income population of Suriname, with a primary focus on ethnic differences in cardiovascular risk. Such data will support the development of effective preventive and intervention strategies aimed at reducing the high cardiovascular disease (CVD) burden in Suriname.

This final chapter presents the key findings of this thesis. First, the main findings are summarized. Second, reflections on the main findings are made, followed by some methodological considerations. Finally, the implications of the findings and recommendations for future research are discussed.

**SUMMARY OF THE MAIN FINDINGS**

Our data showed that more than three-third (77%) of this urban Surinamese adult population had at least one cardiovascular risk factor: hypertension (40%), diabetes mellitus (22%), dyslipidemia (41%), obesity (37%) or tobacco smoking (18%) (Chapter 4). An additional 22% was prehypertensive, prediabetic, overweight or had borderline dyslipidemia, resulting in a mere 1% of the population having an optimal cardiovascular risk factor profile. In those aged 40 years and younger, 62% had at least one cardiovascular risk factor and only 2% had an optimal cardiovascular risk factor profile (Chapter 4).

Marked differences were seen in the prevalence of traditional cardiovascular risk factors across the 4 ethnic groups (Chapter 4). Crude hypertension prevalence was highest in Creole (48%), which significantly differed from that of Maroons (38%) and South-Asians (37%). South-Asians had the highest crude prevalence of diabetes and dyslipidemia (respectively, 30% and 52%), followed by Indonesians (25% and 47%) and Creole (22% and 37%). In Maroons, the prevalence of diabetes and dyslipidemia was relatively low (respectively, 11% and 27%). For general obesity, no crude differences were seen between the 4 ethnic groups.

After dichotomizing the ethnic groups into an African and Asian ancestry population, crude hypertension prevalence did not differ between Africans and Asians (Chapter 4, 7, 8). However, after adjustment for sex, age, body mass index (BMI), and educational level, those of African ancestry were more likely to have hypertension compared to their Asian counterparts (Chapter 4). Diabetes mellitus was more often seen in persons of Asians ancestry, both with HbA1c criteria (Chapter 4) and with fasting plasma glucose criteria (Chapter 7). Also, dyslipidemia was more prevalent in persons of Asian ancestry than in those of African ancestry (Chapter 4 and 7). For general obesity, no differences
were seen between African and Asian ancestry participants (Chapter 4, 6, 7). However, abdominal obesity was substantially more prevalent in Asians compared to Africans (Chapter 5 and 6). Body composition assessments showed that Asians had lower fat-free mass and a higher fat percentage at similar or lower BMI levels as their African counterparts (Chapter 5). In addition, Chapter 5 suggested that of body composition measures, measures for abdominal obesity such as waist circumference should be used to accurately identify persons at risk for CVD. Regarding behavioural risk factors, the prevalence of smoking was similar in Asians and Africans (Chapter 6). Asians were slightly more physically active than Africans (Chapter 6). Meeting the physical activity recommendations was associated with lower obesity prevalence in the total population (Chapter 6). Also, ethnic differences existed in the association between obesity and physical activity characteristics, with leisure time activity and the overall duration of the activity being associated with lower odds for obesity in the African population but not in the Asian population (Chapter 6). In the Asian population, no association could be established between different physical activity characteristics and obesity (Chapter 6).

In addition to traditional cardiovascular risk factors, we assessed early organ damage, which was prevalent in 22% of the population. The majority of these individuals had increased arterial stiffness (77%) (Chapter 4). Moreover, we found that increased arterial stiffness varied by ethnic group (Chapter 7). Individuals of Asian ancestry had a substantially higher pulse wave velocity (PWV) of approximately 1 m/s compared to those of African ancestry, after adjustment for age and blood pressure (BP) (Chapter 7). This ethnic difference in PWV could not be explained by differences in other cardiovascular risk parameters, including fasting glucose, lipid spectrum, BMI, and waist circumference (Chapter 7).

Our findings showed that in this urban Surinamese population hypertension awareness, treatment, and control were suboptimal, with no differences between the ethnic groups (Chapter 4 and 8). We compared our data with those on Surinamese living in the Netherlands (Chapter 8). This comparison demonstrated that in both countries, hypertension is highly prevalent and BP levels poorly controlled. Yet, those living in Suriname, particularly women, bore a higher burden of hypertension with lower levels of control. Age, waist circumference, and BMI were important determinants of hypertension. Therefore, we recommend the design and implementation of preventive programs aimed at the early detection of hypertension and (abdominal) obesity prevention in order to reduce the high hypertension burden in urban Suriname (Chapter 8).
REFLECTION ON THE MAIN FINDINGS

Urban Suriname bears a high cardiovascular risk factor burden

In many low- and middle-income countries (LMIC), the lack of data on cardiovascular risk factors hampers the design and implementation of effective prevention strategies. This thesis provides important information on the status quo of cardiovascular risk factors and early organ damage in urban Suriname. Our extensive cardiovascular assessment indicates that the burden of cardiovascular risk factors is high in this middle-income population, with only 1% of the adult population having an optimal cardiovascular risk profile, the coexistence of multiple cardiovascular risk factors, also in the young, and the suboptimal levels of control. An increase in CVD of epidemic proportions may be anticipated, unless drastic preventive measures are taken.

The prevalence of cardiovascular risk factors in Suriname has nearly doubled over the past 35 years. It is important to bear in mind that the HELISUR study was conducted before the economic crisis in 2015. Due to excessive inflation rates, the availability and affordability of medicines has decreased in Suriname. Furthermore, by definition, a person from a LMIC has only a limited amount of money available that can be spent on health care, such as medicines. If medicine prices exceed the budget, persons may discontinue their treatment regime. Also, a study in Suriname found that the most important determinant of adequate food intake was the level of income. A limited budget, therefore, threatens not only pharmacological treatment, but also the possibility to live a healthy lifestyle. We hypothesize that the current cardiovascular health status of the urban population might be even worse.

The high hypertension burden in Suriname is further illustrated by the comparison with Surinamese living in a high-income country (HIC). We found a higher prevalence of hypertension in women living in Suriname compared to their counterparts living in the Netherlands. This is consistent with earlier studies, observing a higher prevalence of hypertension in LMIC than HIC. However, these studies were conducted among heterogeneous populations in terms of ethnicity. Studies among more homogenous groups that migrated from a LMIC to a HIC show different results with regards to hypertension prevalence. For example, a recent study among African migrants (Ghanaians) living in Western Europe and non-migrants living in rural and urban Ghana found a clear gradient in the prevalence of hypertension. Hypertension prevalence increased from rural through urban Ghana to Europe. In our comparison between Surinamese living in a LMIC versus HIC, we found that this gradient of hypertension from LMIC to HIC does not seem to apply. In fact, it was the opposite for some groups, particularly women. If major
efforts are not made to prevent rapid increases in hypertension in LMIC, the current gradient seen in many populations may disappear, as already observed in Surinam.

Comparing the prevalence of 4 major cardiovascular risk factors with other studies conducted in LMIC shows that our prevalence was generally within the reported range.\textsuperscript{8,9,12,13,14,15} Recently, the Suriname Health Study, based on the WHO STEPwise approach, was conducted in Surinam.\textsuperscript{16} Overall, a lower prevalence was reported of hypertension, diabetes (fasting plasma glucose criteria), and general obesity of respectively 26%, 13%, and 26%\textsuperscript{17,18,19}. Differences in the study design and methods may explain the different prevalences found. First, rural and semirural areas were included in the Suriname Health Study. In those areas, the adoption of a western lifestyle may be less pronounced, resulting in a lower prevalence of cardiovascular risk factors.\textsuperscript{20,21,22} This is also reflected in the findings of the Suriname Health study. For example, persons living in the rural interior were significantly less likely to have obesity and diabetes compared to those living in urban areas.\textsuperscript{18,23} The lower prevalence of cardiovascular risk factors might be further explained by the fact that participants of the Suriname Health Study were on average younger, possibly due to the lower age inclusion criteria (15–65 years compared to 18–70 years in HELISUR).\textsuperscript{10} Participants of the Suriname Health Study had a median age of 35 years, whereas in HELISUR the median age was 44 years.\textsuperscript{17,24} Also, a different distribution of ethnic groups might have accounted for a varying prevalence of cardiovascular risk factors. The HELISUR study included more South-Asians and Creole but less Maroons than the Suriname Health Study. Although these differences in ethnic distribution adequately reflect the population of interest (i.e. relatively more South-Asians and Creole and less Maroons live in the capital compared to the rural interior)\textsuperscript{25}, it may contribute to the overall higher prevalence of risk factors seen in the HELISUR study, as South-Asians and Creole generally had a higher cardiovascular risk factor burden than Maroons. Finally, BP measurements were repeated three times in the Suriname Health Study instead of two times in the HELISUR study. This may added to the lower prevalence of hypertension in the Suriname Health Study compared to HELISUR.\textsuperscript{26}

**Cardiovascular risk varies between ethnic groups**

Our data highlight differences in cardiovascular risk between ethnic groups. Individuals of Asian ancestry had substantially more often diabetes and dyslipidemia than those of African ancestry. Furthermore, they had a higher PWV than individuals of African ancestry, even when adjusted for (or in the absence of) cardiovascular risk factors. For hypertension, the difference between ethnic groups was less evident. Crude prevalence of hypertension was substantially higher in Creole than in South-Asians and, remarkably, than in Maroons. However, Maroons were also substantially younger and the
difference in hypertension between Creole and Maroons disappeared after adjustment for age. Comparing the pooled African subgroup with the pooled Asian subgroup, those of African ancestry were more often hypertensive after adjustment for confounding variables.

Ethnic disparities in cardiovascular risk factors parallel the ethnic differences seen in established CVD, with hypertension-related organ damage and stroke being more prevalent among African subgroups and coronary heart disease being more prevalent among Asian subgroups.27,28,29,30

Ethnic differences in cardiovascular risk are not easily explained. Nevertheless, several factors have been suggested to act as contributors, which can largely be classified as biological contributors, non-biological contributors and (epi)genetic factors.

**Biological contributors:** Asian subgroups exhibit a greater tendency towards visceral fat deposition than African or other subgroups. This is in turn strongly associated with a range of metabolic disturbances, such as impaired glucose tolerance and dyslipidemia.32 In the current thesis, we found that at similar or lower BMI, Asians had greater waist measures and were more often abdominally obese than Africans. This is in line with the international literature and supports the adoption of lower waist circumference thresholds for Asian populations compared to other ethnic populations.33,34,35 In addition, populations of Asian ancestry have a higher degree of insulin resistance and lower β-cell insulin secretion, independent of adiposity, which might explain the high prevalence of diabetes.36 In African ancestry populations, greater salt sensitivity,37 abnormalities in salt transport,38 blunted nocturnal dipping,37 and enhanced vasoconstriction39 have been proposed as contributors to the higher hypertension burden.

**Non-biological contributors:** Besides biological variations between ethnic groups, health behaviour and non-biological contributors, such as the social environment and ethnic discrimination, are major determinants for ethnic differentials in cardiovascular health. Since mid-20th century, cardiovascular risk factors have escalated worldwide, with clear differences in rural and urban areas, suggesting cardiovascular risk factors are a result of industrialization and determined by lifestyle choices.27 Furthermore, widely varying prevalence of cardiovascular risk factors were seen within populations of the same ancestry living in different environments.11,40 Also, in our study, we found differences in hypertension between individuals of African descent living in urban Suriname compared to those living in urban areas in the Netherlands, which point towards important and modifiable components of risk. Similarly, in the Suriname Health Study in Suriname, the highest and lowest prevalence of hypertension was found in respectively Creole
and Maroons, which are both considered persons of African ancestry.\textsuperscript{17} This suggests a significant impact of environment and/or lifestyle on the development of cardiovascular risk.

The majority of the studies on ethnic differences are conducted in HIC, in which other ethnic groups are predominantly compared to the Caucasian population as reference group. Differences in socio-economic status and perceived ethnic discrimination may obscure the relationship between ethnicity and cardiovascular risk factors. For example, African populations with lower socioeconomic status living in HIC, such as the United States, develop hypertension more frequently than is anticipated based on their anthropometric and measurable socioeconomic risk factors.\textsuperscript{41} This demonstrates the importance of the social environment in the assessment of (hypertension) risk. In Suriname, however, it could be speculated that the differences in socioeconomic status and ethnic discrimination between Surinamese of African and Asian ancestry are less pronounced. Yet, ethnic differences in cardiovascular risk were found.

\textit{(Epi)genetics:} To date, genetic studies do not support the hypothesis of excess heritable risk among Asian or African subgroups compared to Caucasian subgroups, and the gene variants that have been associated with BP and insulin resistance have similar effects in all ethnic groups.\textsuperscript{42,43} However, epigenetic variation in response to environmental exposures can influence the phenotype, but also depends on the genotype.\textsuperscript{44} This might contribute to inter-individual variability in gene expression, offering an attractive explanation for ethnic differences in cardiovascular risk. In the current study, however, information on (epi)genetic factors was not available.

Placing our results in the context of the existing knowledge, we cannot state with confidence that African and Asian subgroups in Suriname are either more susceptible or more exposed to factors that influence the development of cardiovascular risk factors. Most likely, it is a combination of both that drives ethnic differences in cardiovascular risk. However, the extent to which each of the factors (i.e. biological, non-biological, (epi)genetic) contribute to ethnic differences remains unclear and might vary for each cardiovascular risk factor.

\textbf{Association between physical activity and obesity differs by ethnicity}

Although physical activity should be promoted in the total Surinamese population in order to reduce obesity, we found ethnic differences in the association between obesity and physical activity characteristics. Leisure time activity and the overall duration of activity were more important in Africans than in Asians in the relation with obesity. Previous studies demonstrated ethnic differences in physical activity in comparison
with Caucasian populations.\textsuperscript{45,46,47,48,49} For example, compared to Caucasians, Asians need to engage in higher physical activity levels to have the same cardio-metabolic risk profile, while Africans need to engage in longer periods of light intensity activity to improve their body composition.\textsuperscript{45,46} Furthermore, it has become evident that there is a need for specific physical activity recommendations to tackle different CV risk factors.\textsuperscript{50,51} Taken together, our results underscore the need for ethnic- and cardiovascular risk factor-specific recommendations for physical activity.

**Hypertension awareness, treatment, control are suboptimal in urban Suriname**

With many effective and inexpensive treatments available, hypertension control and prevention of subsequent hypertension-related diseases should be achievable.\textsuperscript{26} Yet, awareness, treatment, and control levels of hypertension were suboptimal in urban Suriname (respectively, 68\%, 56\%, and 20\%). Women were more often aware, treated, and controlled for hypertension than men. This is consistent with previous studies and might be related to a higher health-seeking behaviour.\textsuperscript{52,53,54} However, comparing women from Suriname to Surinamese women living in the Netherlands showed that women living in Suriname were less aware and, despite higher treatment levels, still less controlled for hypertension than their counterparts living in the Netherlands. This was in contrast to men living in Suriname, who had similar awareness, treatment, and control levels as Surinamese men in the Netherlands. Reasons behind this pattern remain unclear, but might relate to gender inequalities that women in LMIC are still facing to date.\textsuperscript{55} Gender inequalities in education, health literacy, income, or employment may limit the ability of women from LMIC to protect their health, for example through a decreased awareness on how to maintain a good (cardiovascular) health or an inability to afford (antihypertensive) medication.\textsuperscript{55,56,57,58} Further studies are needed to guide interventions aimed at improving these patterns.

No ethnic differences in the awareness, treatment, and control for hypertension were found. However, this result should be viewed with caution, as the ethnic differences in hypertension awareness, treatment, and control were not the primary outcomes of the study and hampered by limited sample sizes.

**METHODODOLOGICAL CONSIDERATIONS**

Each chapter in this thesis provides the limitations relevant to that specific study. In this section, we discuss several methodological considerations of general importance.
Bias

Bias can be defined as a systematic difference between the results of a study and the true state of affairs. It can create a spurious association (i.e. an overestimation of an effect) or mask a real one (i.e. an underestimation of an effect). In health studies, bias can broadly be categorized as either selection bias or information bias.

Selection bias

Selection bias occurs when participants included in the study are not representative of the population to which the results will be applied, e.g. persons who agreed to participate in a study may differ from those who did not agree to participate. As it was not feasible to use the municipality register and randomly select persons, we had to adapt the selection procedure to the local situation. Therefore, we used randomly selected enumeration areas, assigned trained interviewers a starting point and a direction of walking using a door-to-door approach. Data collected with a door-to-door approach avoids selection bias affecting hospital data in LMIC where universal health coverage is uncommon. Furthermore, to reduce selection bias, the interviewers had to visit every household up to a maximum of three times until all household members between the ages of 18-70 years were included or stated a refusal. To warrant the cross-sectional nature of the study, we updated the questionnaires at the day of the physical examination. To minimize no-shows, we made appointments through cell phones on short notice, in combination with text message prompting. Response rates may be considered adequate: 72% for the questionnaires and 78% for the physical examination. Unfortunately, we do not have information on differences between responders and non-responders at this stage. However, we can use the Census data of Paramaribo (i.e. the population of interest) to evaluate whether our sample is representative for the population of Paramaribo (Table 1). This comparison reveals that participants of the HELISUR study were more likely to be women, which is commonly observed in surveys, and more likely to be South-Asian and less likely to be Creole, compared to the general population of Paramaribo. This selection towards more women and South-Asians may have led to an overestimation of crude prevalence estimates of those risk factors that were associated with female sex and South Asian ancestry, such as obesity and diabetes mellitus. This may affect the generalisability of our findings to the urban population. Subjecting the data to a weighing procedure would enable making inferences to the entire population, but was not done in the present study. In the Suriname Health Study, data were subjected to a weighting procedure, transforming the dataset into a nationally representative sample. The prevalence of obesity and diabetes mellitus in the urban areas was lower in this study compared to our data.
When we compared data from the participants who were interviewed but not examined with the participants who were examined, we found no differences in the distribution of sex. However, participants who were interviewed but not examined were more often Maroon (179 [29%] vs. 216 [19%], \(p<0.01\)), less often South Asian (152 [24%] vs. 393 [34%], \(p<0.01\)), and more likely to be younger (35 vs. 42 years, \(p<0.01\)).

Although the vast majority of the Surinamese (73%) lives in an urban area,\(^{25}\) it is important to keep in mind that the urban population may not be representative for the entire country. Urban residents had a worse cardiovascular risk profile than their rural counterparts, regarding diabetes and obesity.\(^{18,23}\) Therefore, we emphasize that the data of the HELISUR study cannot be extrapolated to the entire population of Suriname and only with caution to the population of Paramaribo.

**Information bias**

Information bias is a bias that arises in a study because of misclassification of the exposure or outcome measurements.\(^{59}\) For example, the presence of hypertension and other cardiovascular risk factors was assessed through measurements within one visit, while repeated tests are required for confirmation of the diagnosis.\(^{26}\) The prevalence of cardiovascular risk factors might therefore be an overestimation. Nevertheless, with epidemiological studies this is a common approach.

Information on several confounding variables (e.g. educational level, medication use, and physical activity) was self-reported and recall bias might have occurred. Persons

<table>
<thead>
<tr>
<th>Sex</th>
<th>Census 2012 – Population of Paramaribo (n=240,924)</th>
<th>HELISUR – Questionnaire (n=1,800)</th>
<th>HELISUR – Questionnaire and physical examination (n=1,157)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>49%</td>
<td>38%</td>
<td>37%</td>
</tr>
<tr>
<td>Women</td>
<td>51%</td>
<td>62%</td>
<td>63%</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Creole</td>
<td>28%</td>
<td>22%</td>
<td>21%</td>
</tr>
<tr>
<td>Maroon</td>
<td>17%</td>
<td>22%</td>
<td>19%</td>
</tr>
<tr>
<td>South-Asian</td>
<td>25%</td>
<td>31%</td>
<td>34%</td>
</tr>
<tr>
<td>Indonesian</td>
<td>11%</td>
<td>8%</td>
<td>9%</td>
</tr>
<tr>
<td>Other/mix</td>
<td>20%</td>
<td>17%</td>
<td>17%</td>
</tr>
</tbody>
</table>

_Footnote Table 1_. Values are proportions. Comparisons are made between the sex and ethnic distribution of the population of Paramaribo\(^{25}\) and that of the HELISUR study population.
who forgot to mention their medication and had normal blood pressures were classified as normotensives instead of controlled hypertensives. The same applied to antihyperglycemic and antihyperlipidemic medication and the respective proportions of diabetics and persons with dyslipidemia. A type of bias that can arise with self-reported data is social desirability bias, in which participants give answers in the direction they perceive are of interest to the researcher or under-report socially unacceptable behaviours. This could be relevant for the assessment of tobacco smoking or physical activity, which may have resulted in a respective under- and overestimation of the proportion of smokers and physically active persons. Nevertheless, as these misclassifications applied to all groups, it is unlikely that these limit the comparability between the ethnic groups.

Confounding
Confounding occurs when we find a spurious association between a potential risk factor and a disease outcome or miss a real association between them because we have failed to adjust for any confounding variables. In this thesis, we dealt with confounding using stratification and adjustment.

Although information on many confounders was available in this study, residual confounding may still be present, as in any observational study. For example, single measurements of confounding variables would be poorly representative of lifetime exposure. Furthermore, information on several potential confounding variables was not collected within the HELISUR study. Early life influences, for example in utero or childhood, may play a strong independent role in determining adult cardiovascular risk, but were not examined. Also, food intake and dietary salt intake are important determinants of cardiovascular risk factors, but were beyond the scope of this paper. A recently published paper of the Suriname Health Study suggested that only 5% of the Surinamese had an overall healthy food intake (i.e. adequate and not excessive). Food intake also differed across ethnic groups with Maroons and Amerindians (mainly from the inlands) consuming less often an adequate food intake but also less often an excessive food intake. Moreover, next to kitchen salt, Surinamese meals contained mostly products high in salt. Given that the majority of the HELISUR participants consumed more than one hot meal per day, there is little doubt that the population salt consumption far exceeds the recommended maximum of 5 g per person per day. As food and salt intake are important determinants of hypertension and a potential confounder in the association between ethnicity and hypertension, this may be a limitation of our study. Overall, residual confounding may have resulted in an overestimation of the estimates.
Note on ethnicity

In this thesis, self-reported ethnicity was used. Although self-reported ethnicity is considered the best variable, we recognize that these categories are arbitrary and that heterogeneity exists within each ethnic group.\textsuperscript{68,69}

Not all analyses in this thesis were stratified for the 4 major ethnic groups. The reason for this was that the analyses were hampered by limited sample sizes and thus would have reduced power to detect a significant effect. Especially, the Indonesian subgroup was small (n=105; 9%), although this accurately reflects their relative small representation within the urban Surinamese population (11%, Table 1). The pooling of the ethnic groups may have led to an underestimation of the estimated difference between African and Asian ancestry populations. For example, the unadjusted prevalence of hypertension was 10% lower in Maroons compared to Creole (38% vs 48%). The same holds true to a lesser extent for the South-Asian and Indonesian ancestry subgroups. Combining the two ethnic groups might have diluted the differences between African and Asian ancestry groups. We acknowledge that this is a limitation for the analyses presented in the chapters.

IMPLICATIONS AND FUTURE DIRECTIONS

Based on the findings of the current thesis and the available literature, several recommendations for research and policy can be made to achieve a Healthier Life in Suriname.

There is need for population-based interventions

The main focus of health care for CVD in many LMIC is secondary prevention.\textsuperscript{70} Patients enter treatment programs after becoming symptomatic, when costly high-technology interventions are needed. However, primary CVD prevention is relatively cheap and has a much greater return (e.g. less premature deaths, reduced economic losses).\textsuperscript{71} The World Health Organization has identified a set of “best buy interventions” that mainly focuses on improvements in salt intake, physical activity, tobacco use, and alcohol consumption.\textsuperscript{71,72} These population-based interventions have proven to be very cost-effective and are appropriate to implement in LMIC such as Suriname, where the health care infrastructure is less developed.\textsuperscript{71,72} In Suriname, a first step in the right direction is made by introducing the Health in All Policies (HiAP) approach in 2017.\textsuperscript{73} The HiAP is a collaborative approach across all levels and sectors of government to improve health, for example, through nutritional labeling on foods high in fat, sugar, and salt or spatial planning to promote physical activity.\textsuperscript{73} Although the formulation of these policies is
promising, the effective implementation and monitoring of these policies might still be a challenge, especially with the limited resources available in Suriname.

**There is a need for intensified screening for and control of hypertension**

With hypertension being responsible for almost half of the CVD deaths, interventions aimed at lowering BP or improving awareness, treatment, and control are of great importance.\(^7^0\) In urban Suriname, hypertension was highly prevalent and started already at a young age (25% of people below the age of 40 years had hypertension). In addition, effective and low-cost drug therapy is globally available. Yet, the levels of awareness and control are disappointing. Routine opportunistic screening for hypertension during regular health care visits provides a simple but reliable way to increase hypertension awareness in LMIC.\(^7^4,7^5\) This screening for high BP should start already early in life. Furthermore, focusing on education can improve hypertension prevalence, awareness, and control levels. However, it is important to recognize culturally and ethnically different perspectives on hypertension and treatment thereof.\(^7^6\) To date, such information is lacking in Suriname, and, therefore, future studies should focus on how cultural and ethnic factors influence management of hypertension in Suriname.

General and abdominal obesity were the most important determinants of hypertension. This highlights the pivotal role of obesity in the hypertension pandemic and warrants the implementation of interventions aimed at (abdominal) obesity prevention. Our results on the association between physical activity and obesity underscore the importance of physical activity in the prevention of obesity. In addition, we found that waist measures were the most suitable body composition measure to assess cardiovascular risk and therefore advocate the use of a waist measure in clinical practice to assess who is at increased risk for CVD.

**There is a need for ethnic-specific research and prevention programs**

Although interventions aimed at early BP screening and obesity prevention should target the population as a whole, a more ethnic-specific approach might be warranted in the prevention of diabetes and dyslipidemia. Persons of Asian ancestry were twice as likely to have diabetes and dyslipidemia compared to those of African ancestry, suggesting that the “one size fits all” approach may not be appropriate for these specific risk factors. Therefore, routine opportunistic screening for diabetes and dyslipidemia may be useful in Surinamese of Asian ancestry.

Given the ethnic differences in cardiovascular risk, it may be useful to register ethnicity in the routine health care data registry. This may be culturally charged due to potential risks (e.g. discrimination or stigmatisation), yet, the appropriate use of ethnicity may
provide valuable information on differences in cardiovascular health of subgroups that warrant further investigation and intervention.

Because we did find differences between the 4 ethnic groups, future research in Suriname should study these ethnic groups separately with a large enough sample size so that the underlying causes of ethnic inequalities in health can be explored. This would also enable the identification of cut-off values specific for the ethnic groups living in Suriname instead of using those validated in white populations or in ethnic groups from other countries.

**There is a need for prospective data and ongoing public health surveillance**

A cross-sectional study design is a correct way to assess the current health status of a population, especially in a low-resource setting. However, the cross-sectional nature of our study implies that causal associations cannot be established. Data presented in this thesis would ideally be the baseline data for a longitudinal study, in which these baseline measurements are repeated during follow-up studies to enable longitudinal analyses on the relationship between ethnicity and incident CVD. For example, continuation of the HELISUR study could elucidate whether Asians with an increased arterial stiffness but without hypertension have a higher risk of developing CVD. Also, it would be valuable to relate body composition measures to hard cardiovascular outcomes instead of CVD risk scores and surrogate intermediate endpoints.

Cardiovascular risk profiles change overtime, in a negative way (e.g. due to the epidemiological transition or an economic crisis) or in a positive way (e.g. due to implementation of effective interventions). To follow trends in cardiovascular risk, it is important to introduce public health surveillance in Suriname, in which a cross-sectional survey is repeated every 5 years. This will also enable the evaluation and adaptation of public health interventions.

**GENERAL CONCLUSION**

Cardiovascular disease is rapidly rising in many low- and middle-income countries. Yet, the lack of data on cardiovascular risk factors hampers the design of effective prevention strategies. The current thesis describes the status quo of cardiovascular risk factors and early organ damage in the middle-income population of urban Suriname. The cardiovascular risk factor burden in urban Suriname is alarmingly high, with only 1% of the adult population having an optimal cardiovascular risk profile, the coexistence of multiple cardiovascular risk factors, also in the young, and the suboptimal levels of
control. An increase in CVD of epidemic proportions may be anticipated, unless drastic preventive measures are taken. Preventive strategies at the population level, such as screening for hypertension and obesity prevention, together with ethnic-specific approaches for diabetes and dyslipidemia in Asian ancestry populations, should be implemented in order to protect the cardiovascular health of urban Surinamese.
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