Cardiovascular disease prevention in the slums of Kenya

van de Vijver, Steven

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PART II

INTERVENTION
CHAPTER 6

Review of community based interventions for prevention of cardiovascular diseases in low- and middle-income countries

Steven van de Vijver, Samuel Oti, Juliet Addo, Ama de Graft-Aikins, Charles Agyemang

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ABSTRACT

Background
An increasing burden of cardiovascular disease (CVD) is occurring in low- and middle-income countries (LMIC) as a result of urbanization and globalization. Low rates of awareness and treatment of risk factors worsen the prognosis in these settings. Prevention of CVD is proven to be cost effective and should be the main intervention. Insight into prevention programmes in LMIC is important in addressing the rising levels of these diseases.

Objective
To evaluate the effectiveness of the community based interventions for CVD prevention programmes in LMIC.

Design

Results
Twenty six studies involving population-based and high-risk interventions have been included in this review. The content of the population intervention were mainly health promotion through media and health education, and the high-risk approach focussed often on education of patients, training of health care providers and implementing treatment guidelines. A few studies had a single intervention on exercising or salt reduction. Most studies showed a significant reduction of cardiovascular risk ranging from lifestyle changes on diet, smoking and alcohol to biomedical outcomes like blood pressure, glucose levels or weight. Some studies showed improved management of risk factors like increased control of hypertension or adherence to medication.

Conclusion
There have been effective community based programmes aimed at reducing cardiovascular risk factors in LMIC but these have generally been limited to the urban poor. Health education with a focus on diet and salt, training of health care providers and implementing treatment guidelines form key elements in successful programs.
BACKGROUND

Cardiovascular diseases (CVD) are the leading cause of mortality worldwide [1]. More than 80% of the global CVD deaths occur in low- and middle-income countries (LMICs), and this percentage is projected to increase even further in the next decade [2, 3]. It is therefore anticipated that in the coming years, the burden of CVD could aggravate the already stretched and poorly responsive health systems of LMICs.

The increasing burden of CVDs is mainly driven by globalization, westernization, industrialization and urbanization [4]. These trends are strongly linked with changes in individual and societal lifestyle such as tobacco use, alcohol consumption, reduced physical activity and adoption of ‘western’ diets that are high in salt, refined sugar and unhealthy fat and oils. These lifestyle factors have been demonstrated to be strong behavioural risk factors for CVD [4]. Overall, LMICs are experiencing rising trends in both behavioural and physiological risk factors for CVD with increasing urbanisation. Several studies have demonstrated that in urban settings, behavioural and physiological risk factors for CVD are higher than in rural areas [5-7]. Moreover, low rates of treatment and control of risk factors such as hypertension have been reported in LMICs, resulting in disproportionately higher morbidity and mortality rates [6, 8].

Prevention of CVD risk has been shown to be both cost effective and scalable even in LMICs [9]. Additionally, focussing on the prevention and management of CVD risk factors will create more effective treatment, lower costs of care and reduce overall morbidity and mortality from CVD [10]. The Institute of Medicine Report on cardiovascular health in LMICs stresses the need for evidence and best practices for cost-effective and sustainable community based strategies for prevention and control of cardiovascular risk factors.

Insight into prevention and control programs for CVD is important in addressing the rising burden of these diseases. Previous interventions in high-income countries have been shown to have
had positive outcomes, and lessons from these may be applicable to LMICs [11, 12]. It is however important to know how these programs can be implemented effectively in LMICs. It has been suggested that a structured integrated programme is most effective in CVD prevention [10]. However, it is difficult to implement this in LMICs where capacity is low, health systems are poorly responsive and political will to effect necessary changes in policy might be lacking. Again, as funding and attention to prevention programs of CVD in these regions has been limited over the years, it will be important for health planners and decision makers to draw on best practices from other settings in the design of CVD prevention and control strategies in LMICs. Previously published studies on cardiovascular disease control in LMICs [9, 13-15], have often lacked practical real-life application. It is essential to identify and evaluate effective strategies implemented in CVD prevention and control programs in LMICs. Even if studies have focused on only a single risk factor they still might provide tools for new prevention programs in these settings that are heavily needed.

Until now the intervention studies that have taken place in LMICs have not yet been evaluated. The main aim of this paper was therefore to assess the effectiveness of the population based intervention studies for CVD prevention in LMIC. Our key research questions were (a) what kinds of community based interventions on CVD prevention have been conducted in LMICs? (b) and which interventions were effective in reducing cardiovascular risk in LMIC?

**METHODS**

We searched through the databases of Pubmed, CINAHLL, EMBASE, LILACS, African index medicus and Google Scholar for studies that were published between 1990 and the 1st of May 2012, and evaluated interventions of community-based prevention for CVD in LMICs among adults (≥18 years) with or without existing risk factors for CVD. The intervention had to be “community-
based”; meaning that the intervention was coordinated through worksites, schools, religious organisations, primary health care centres or other settings closely related to the participants in line with the American Heart Association Framework for public health practice for CVD prevention (Figure 1).

Based on the American Heart Association Guide for Improving Cardiovascular Health at the Community Level [16], we defined prevention of CVD as healthy lifestyle adjustments in order to reduce one or more risk behaviours (such as overweight or smoking) or screening and management of risk factors like hypertension and diabetes. We evaluated studies that compared intervention group with the control group without intervention, or compared the group before and after the intervention on any of the following outcomes: systolic and/or diastolic blood pressure, hypertension, glucose levels, HbA1c-levels, body weight, body mass index (BMI), waist circumference, physical activity, salt intake, fat intake, smoking, alcohol intake, and the rates of awareness, treatment and control of hypertension and diabetes. In addition, we evaluated other outcomes such as cost effectiveness, feasibility and
training on CVD prevention if this information was available. Because our focus was on community based interventions, all studies on hospital-based intervention studies were excluded from this review. In order to minimise bias from studies with small numbers of participants or short period of time we included only studies with ≥250 participants and follow up period of minimum one year. Furthermore, non-English language published studies were excluded as there were no resources for accurate translations.

For this review, we defined ‘medium to high risk group’ as people having elevated blood pressure levels (blood pressure ≥140/90 mmHg), elevated glucose levels (fasting glucose >5.6 mmol/l or random blood sugars >11.0 mmol/l) or overweight (BMI≥25 kg/m² or waist circumference >102cm among men and >88cm among women).

RESULTS

Study characteristics
Twenty six studies were included in this review (Figure 2). The overview of the articles is in Table 1.

The selected studies were conducted between 1979 and 2008, and published between 1993 and 2011. The median sample size was 11660 with a range from 284 [17] to 120,000 [18] participants and the length of follow up varied between 1 year [19] and 8 years [18]. Most of the studies were conducted in urban or mixed urban and rural setting.

Twelve studies were based on population level, three studies focused on population level and medium or high risk groups, and eleven studies focussed on medium or high risk groups.

Among the fifteen population-based studies there were national or regional programmes that included health promotion through media and approached the overall population with community programs targeting schools, worksites and other public meeting places. Generally, these programmes aimed to raise knowledge, awareness and healthy behaviour at different levels such as diet, ex-
Excise, smoking and alcohol. Five population-based interventions focused on a specific risk factor like salt reduction [20], diet adjustments [21] and exercising [22-24]. A few of the interventions [18, 22] were strictly related to the worksite.

Among the fourteen studies focusing on medium or high risk patients, most interventions involved providing health education to patients, training of health care staff and introduction of standardized treatment including guidelines. Two programs studied outcomes of task shifting, mostly from doctor to nurses or clinical officers [17, 25] and one study [26] concentrated only on implementation of salt substitution among medium or high risk patients.
<table>
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<tr>
<th>Source</th>
<th>Location</th>
<th>Setting</th>
<th>Target</th>
<th>Period</th>
<th>Numbers</th>
<th>Age</th>
<th>Study design</th>
<th>Aim</th>
<th>Intervention</th>
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<tbody>
<tr>
<td>Damiâo et al 2010</td>
<td>Brazil</td>
<td>Urban</td>
<td>Population</td>
<td>2005-2007</td>
<td>575</td>
<td>30 yrs &lt;</td>
<td>Non-controlled experimental</td>
<td>Impact of nutritional advice on diets</td>
<td>Nutrition training on individual and group level</td>
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<td>Source</td>
<td>Location</td>
<td>Setting</td>
<td>Target</td>
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<td>Krishnan et al 2011</td>
<td>India, Ballabgarh</td>
<td>Urban/rural</td>
<td>Population</td>
<td>2004-2007</td>
<td>5143</td>
<td>41.5 yrs mean</td>
<td>Non-controlled experimental</td>
<td>Evaluation of health program on CVD risk factors</td>
<td>Health promotion through media, health education, set up clinic</td>
</tr>
<tr>
<td>Krishnan et al 2011</td>
<td>Indonesia</td>
<td>Urban</td>
<td>Population</td>
<td>2004-2007</td>
<td>1806</td>
<td>44.3 yrs mean</td>
<td>Non-controlled experimental</td>
<td>Evaluation of health program on CVD risk factors</td>
<td>Health promotion through media, health education, set up clinic</td>
</tr>
<tr>
<td>Sarrafzadegan et al 2009</td>
<td>Iran, Isfahan</td>
<td>Urban/rural</td>
<td>Population</td>
<td>2000-2004</td>
<td>12315</td>
<td>18 yrs &lt;</td>
<td>Intervention trial</td>
<td>Evaluation of health program on CVD risk factors</td>
<td>Health promotion through media, health education, training health care</td>
</tr>
<tr>
<td>Huang et al 2011</td>
<td>China, Hubei</td>
<td>Urban/rural</td>
<td>Population</td>
<td>2003-2006</td>
<td>1632</td>
<td>35 yrs &lt;</td>
<td>Intervention trial</td>
<td>Evaluate effect of education on knowledge and CVD risk factors</td>
<td>Health education, training health care staff</td>
</tr>
<tr>
<td>Source</td>
<td>Location</td>
<td>Setting</td>
<td>Target</td>
<td>Period</td>
<td>Numbers</td>
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<tr>
<td>Khosravi et al 2010</td>
<td>Iran, Isfahan</td>
<td>Urban/rural</td>
<td>Population/risk</td>
<td>2001-2007</td>
<td>12514</td>
<td>18 yrs &lt;</td>
<td>Intervention trial</td>
<td>Evaluate effect of treatment program</td>
<td>Health promotion through media, health education, training health care</td>
</tr>
<tr>
<td>Van Rossouw et al 1993</td>
<td>South Africa</td>
<td>Rural</td>
<td>Population/risk</td>
<td>1979-1983</td>
<td>7188</td>
<td>15-64 yrs</td>
<td>Cross sectional surveys</td>
<td>Evaluation of health program on CVD risk factors</td>
<td>Health promotion through media and health education</td>
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<td>CSSS group 2007</td>
<td>China, northern</td>
<td>Rural</td>
<td>Risk group</td>
<td>2004-2005</td>
<td>608</td>
<td>55 yrs &lt;</td>
<td>Randomized control trial</td>
<td>Impact of salt substitutes on BP control</td>
<td>Introducing salt substitutes</td>
</tr>
<tr>
<td>Gill et al 2008</td>
<td>South Africa</td>
<td>Rural</td>
<td>Risk group</td>
<td>18 months</td>
<td>284</td>
<td>56 yrs mean</td>
<td>Non-controlled experimental</td>
<td>Evaluate nurse-led diabetes program</td>
<td>Guidelines, training and patient education</td>
</tr>
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<td>Harati et al 2010</td>
<td>Iran, Teheran</td>
<td>Urban</td>
<td>Risk group</td>
<td>2002-2005</td>
<td>8212</td>
<td>20 yrs &lt;</td>
<td>Cluster controlled trial</td>
<td>Impact of lifestyle modification on CVD risk factors</td>
<td>Intensive health education (smoking, nutrition, exercise) among diabetes patients</td>
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<tr>
<td>Isaidakis et al 2011</td>
<td>Cambodia</td>
<td>Rural</td>
<td>Risk group</td>
<td>2002-2008</td>
<td>2858</td>
<td>18 yrs &lt;</td>
<td>Non-controlled experimental</td>
<td>Describe and evaluate HT treatment program</td>
<td>Health education and treatment</td>
</tr>
<tr>
<td>Jafar et al 2009</td>
<td>Pakistan</td>
<td>Urban</td>
<td>Risk group</td>
<td>2004-2007</td>
<td>4023</td>
<td>40 yrs &lt;</td>
<td>Randomized control trial</td>
<td>Assess effect of treatment program on BP and related risk factors</td>
<td>Health education households and training health care providers</td>
</tr>
<tr>
<td>Source</td>
<td>Location</td>
<td>Setting</td>
<td>Target</td>
<td>Period</td>
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<td>Kengne et al 2009</td>
<td>Cameroon</td>
<td>Urban/rural</td>
<td>Risk group</td>
<td>1998-2000</td>
<td>454</td>
<td>56 yrs mean</td>
<td>Non-controlled experimental</td>
<td>Describe and evaluate HT treatment program</td>
<td>Guidelines and training nurses</td>
</tr>
<tr>
<td>Onat et al 2003</td>
<td>Turkey</td>
<td>Urban/rural</td>
<td>Risk group</td>
<td>12 months</td>
<td>2012</td>
<td>40-70 yrs</td>
<td>Non-controlled experimental</td>
<td>Describe and evaluate HT treatment program</td>
<td>Introducing guidelines for high risk patients</td>
</tr>
<tr>
<td>Ramachandran et al 2006</td>
<td>India</td>
<td>Urban/rural</td>
<td>Risk group</td>
<td>2001-2004</td>
<td>531</td>
<td>35-55 yrs</td>
<td>Randomized control trial</td>
<td>Impact of lifestyle modification on prevention of diabetes</td>
<td>Mobile clinic, treatment and lifestyle advice</td>
</tr>
<tr>
<td>Salazar et al 2005</td>
<td>Argentina</td>
<td>Rural</td>
<td>Risk group</td>
<td>1997-2003</td>
<td>1377</td>
<td>15-75 yrs</td>
<td>Non-controlled experimental</td>
<td>Assess effect of treatment program on BP and related risk factors</td>
<td>Health education, free medication</td>
</tr>
</tbody>
</table>
Study outcomes

In Table 2 there is an overview of the outcomes of the different studies with the same ranking of population-based intervention, mixed population and medium or high risk patients, and finally only medium or high risk patients. Interventions were evaluated through different study designs including randomized control trial [26-28], cluster controlled trial [18, 29-32], non-controlled experimental [17, 19, 22-25, 33-37] and cross-sectional surveys [38-40].

Blood pressure and hypertension

Nineteen studies measured the systolic blood pressure (SBP), and fifteen of them included the diastolic blood pressure (DBP) as well, whereas six studies evaluated prevalence of hypertension. Except one [22] all studies showed significant reduction in blood pressure or hypertension prevalence. Reductions in mean systolic/diastolic ranged from 0.1/0.5 mmHg by worksite exercise breaks intervention [22] to 55.5/28.7 mmHg through introduction of a hypertension management structure with guidelines and training of staff [36]. The majority of programs with significantly decreased blood pressures contained health education, training of health care staff and introduction of guidelines.

Glucose, HB1Ac and diabetes

Four studies [23, 25, 31, 38] evaluated fasting glucose levels, one study [17] evaluated HB1Ac and 2 [28, 30] evaluated absolute risk reduction in diabetes prevalence. Except one [38], all the studies on glucose and HB1Ac found significant reductions in mean values. Ramachandran et al. 2006 found a significant reduction of 15.5% incidence of diabetes whilst Khosravi et al. only found a meagre reduction of 0.8%. Most of the studies that had significant reduction were based on health education and training of health care staff with guidelines.
Weight, BMI, waist circumference
Less than half, (7 out of 16 studies) found significant reductions in body sizes including in weight [23, 25, 31, 34], BMI [17, 22, 39], waist circumference [23, 31, 33] and prevalence of overweight [33]. Although two studies [17, 38] showed an increase after the intervention in respectively prevalence of obesity and average BMI. Health programs with a focus on physical activity and diet showed significant results.

Behaviour change (physical activity diet and smoking)
Seven out of ten studies found a significant increase in physical activity whereas two studies [32, 33] showed a decrease in the follow up. Most of the successful interventions to improve physical activity contained health education assisted by intensive training and coaching of exercises. Improved diets were shown through reduction of salt, fats, sugar and alcohol or increased intake of fruits and vegetables in ten out of thirteen studies mainly through health education interventions. Five out of nine studies showed a significant reduction in smoking, whereas one study showed an increase of intention to quit smoking [29]. National and regional programs with health promotion through media and health education showed to be effective interventions for smoking cessation.

Management and awareness of risk factors and retention of participants
Several studies showed a significant increase in knowledge of healthy lifestyle [39, 41] in awareness of hypertension [30, 41], treatment of hypertension [18, 30, 37, 41], control of hypertension and diabetes [18, 30, 35, 41, 42] and adherence [28, 29] after the intervention. Of the eight studies that measured retention of medium and high risk patients for follow up, only two [26, 28] of them had at the end of the study more than 80% of the initial participants still in the study, and two were below 50% [19, 25]. Studies that raised significantly levels of knowledge and behaviour contained intense health education through various methods (classes and print). Treatment and control of hypertension and di-
Table 2: Overview of results from selected studies

<table>
<thead>
<tr>
<th>Source</th>
<th>Blood pressure</th>
<th>Glucose/ HbA1c</th>
<th>Weight reduction</th>
<th>Physical activity</th>
<th>Diet</th>
<th>Smoking</th>
<th>Manage Risk Factor</th>
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<tbody>
<tr>
<td>Almeida-Pittito et al 2010</td>
<td>No data available</td>
<td>Not significant</td>
<td>Reduction weight among 42%* participants pre vs post</td>
<td>Increase in physical activity among 7.4%* pre vs post</td>
<td>Reduction saturated fats in diet among 74.5%<em>, increase in fruit intake 39%</em> pre vs post</td>
<td>No data available</td>
<td>LTFU 2%</td>
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<tr>
<td>Cappucio et al 2006</td>
<td>Reduction SBP 2.5mmHg (-1.45 to 6.54), DBP 3.9mmHg (0.78 to 7.11)* vs control</td>
<td>No data available</td>
<td>No data available</td>
<td>No data available</td>
<td>No significant reduction in salt intake vs control</td>
<td>No data available</td>
<td>No data available</td>
</tr>
<tr>
<td>Chen et al 2007 (rural)</td>
<td>Reduction in SBP 1.4mmHg in men, 3.4mmHg* in women vs control. DBP not significant</td>
<td>No data available</td>
<td>No data available</td>
<td>No data available</td>
<td>Reduction alcohol intake among men 10.4%* vs control</td>
<td>Reduction smoking among men 7.4%* vs control</td>
<td>No data available</td>
</tr>
<tr>
<td>Chen et al 2007 (urban)</td>
<td>Reduction SBP 1.9mmHg, reduction DBP 2.2mmHg* vs control</td>
<td>No data available</td>
<td>No data available</td>
<td>No data available</td>
<td>Reduction in salt intake of 3.9 grams/ day* vs control</td>
<td>No data available</td>
<td>Increase in treatment of HT 46.3%<em>, increase control HT 34.5%</em> vs control</td>
</tr>
<tr>
<td>Source</td>
<td>Blood pressure</td>
<td>Glucose/ Hba1c</td>
<td>Weight reduction</td>
<td>Physical activity</td>
<td>Diet</td>
<td>Smoking</td>
<td>Manage Risk Factor</td>
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<tr>
<td>Damião et al 2010</td>
<td>Reduction among men in SBP 7.3mmHg**, DBP 4.5mmHg**, Reduction among women SBP 6.0mmHg**, DBP 3.9mmHg** pre vs post</td>
<td>Reduction among men fasting glucose 7.2mg/dl (4.72 to 9.71)<strong>, among women 3.7mg/dl (1.71 to 5.75)</strong></td>
<td>Reduction among men in weight 0.9kg (0.58 to 1.27)** and WC 2.0cm (1.05 to 3.01), among women weight 0.4kg (0.09 to 0.71)<strong>, WC 3.15cm (2.54 to 3.76)</strong> pre vs post</td>
<td>No significant increase in physical activity pre vs post</td>
<td>Reduction of fat intake among men 0.2kg/day(-3.96 to 4.45), among women 0.4kg/day (6.20 to 10.76)*, alcohol reduction not significant pre vs post</td>
<td>No data available</td>
<td>No data available</td>
</tr>
<tr>
<td>Dowse et al 1995</td>
<td>Reduction among men in hypertension 2.9% (1.1 to 4.9)<strong>, among women 1.5% (0.0 to 3.0)</strong></td>
<td>No significant decrease pre vs post</td>
<td>Increase among men of obesity 1.9% (0.7 to 3.1)<em>, among women 4.8% (3.0 to 6.6)</em></td>
<td>Increase among men in activity 5.2% (2.9 to 7.5)<strong>, among women 1.4% (0.6 to 2.2)</strong></td>
<td>Reduction among men heavy alcohol consumption 23.8% (21.7 to 25.9)<strong>, among women 2.0% (1.3 to 2.7)</strong></td>
<td>Reduction among men 11.0% (8.1 to 13.9)<strong>, among women 3.2% (2.0 to 4.4)</strong></td>
<td>No data available</td>
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<td>Source</td>
<td>Blood pressure</td>
<td>Glucose/Hba1c</td>
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<td>Krishnan et al 2011 (India)</td>
<td>Reduction among men in prevalence HT 8.6%<em>, SBP 2.1mmHg</em>, DBP 1.2mmHg*, among women prevalence HT 1.7%, SBP 2.6mmHg*, DBP 1.0mmHg pre vs post</td>
<td>No data available</td>
<td>Increase among men in prevalence overweight 0.2%, among women 2.0%</td>
<td>Reduction among men in activity 3.0%, among women increase inactivity 18.3%*</td>
<td>Reduction among men in alcohol 1.7%, among women 0.1%</td>
<td>Increase among men in smoking 6.4%, among women 2.3%<em>, among women SBP 8.6%</em>, FBG 7.2%*</td>
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<td>Krishnan et al 2011 (Indonesia)</td>
<td>Reduction among men in prevalence HT 5.2%<em>, SBP 13.8mmHg</em>, DBP 7.5mmHg*, among women prevalence HT 5.6%<em>, SBP 16.0mmHg</em>, DBP 9.5mmHg* pre vs post</td>
<td>No data available</td>
<td>Reduction among men overweight 11.5%, reduction among women in WC 13.6%*</td>
<td>Reduction among men in activity 3.9%, among women increase inactivity 19.2%*</td>
<td>Reduction among men in alcohol 3.5%, among women 0.3%</td>
<td>Increase among men in smoking 6.5%, among women 0%</td>
<td>Increase among men in measurement of SBP in last year 11.6%, and FBG 56.3%, among women SBP 2.8%, FBG 62.1%*</td>
</tr>
<tr>
<td>Source</td>
<td>Blood pressure</td>
<td>Glucose/ HbA1c</td>
<td>Weight reduction</td>
<td>Physical activity</td>
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<td>Smoking</td>
<td>Manage Risk Factor</td>
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<tr>
<td>Lara et al 2008</td>
<td>Increase among men SBP 0.1mmHg, DBP 0.7mmHg, Reduction among women SBP 1.0mmHg, DBP 0.5mmHg pre vs post</td>
<td>No data available</td>
<td>Reduction among men BMI 0.43* and waist circumference 1.9cm**, among women BMI 0.25, waist circumference 1.4cm*</td>
<td>No data available</td>
<td>No data available</td>
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</tr>
<tr>
<td>Mohan et al 2006</td>
<td>No data available</td>
<td>No data available</td>
<td>Increase exercise 44.5% pre vs post*</td>
<td>No data available</td>
<td>No data available</td>
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</tr>
<tr>
<td>Sarrafzadegan et al 2009</td>
<td>No data available</td>
<td>No data available</td>
<td>Decrease physical activity 0.6-9.6%*</td>
<td>Increase in healthy diet 17-21%<em>, in healthy lifestyle 30.5%</em></td>
<td>Reduction in smoking 1.5-3.0% pre vs post</td>
<td>No data available</td>
<td>No data available</td>
</tr>
<tr>
<td>Yu et al 1999</td>
<td>Reduction among men in prevalence in HT 2%<em>, SBP 0%, among women prevalence of HT 2%</em>, SBP 2mmHg</td>
<td>No data available</td>
<td>Reduction among men in prevalence overweight 2%, among women 3%</td>
<td>Reduction in salt intake 6.0%</td>
<td>No data available</td>
<td>No data available</td>
<td>No data available</td>
</tr>
<tr>
<td>Source</td>
<td>Blood pressure</td>
<td>Glucose/ HbA1c</td>
<td>Weight reduction</td>
<td>Physical activity</td>
<td>Diet</td>
<td>Smoking</td>
<td>Manage Risk Factor</td>
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<tr>
<td>Huang et al 2011</td>
<td>Reduction prevalence HT 12.9%* pre vs post</td>
<td>No data available</td>
<td>No data available</td>
<td>Increase in exercise 16.4%* pre vs post</td>
<td>Reduction in alcohol 4.2%<em>, salt intake 30%</em>, fat intake 9.1%* pre vs post</td>
<td>Reduction in smoking 3.5% pre vs post</td>
<td>Increased knowledge on healthy lifestyle 6.6%-55.5%<em>, increase awareness HT 18.5%</em>, treatment HT 12.7%<em>, control HT 24.3%</em> pre vs post</td>
</tr>
<tr>
<td>Khosravi et al 2010</td>
<td>Reduction in prevalence HT 3.3%** vs control. Reduction SBP 3.2mmHg** pre and post</td>
<td>Reduction prevalence DM 0.8% vs control</td>
<td>Reduction BMI 2.5% vs control</td>
<td>No data available</td>
<td>No data available</td>
<td>No data available</td>
<td>Increase in awareness HT 9.4%<strong>, treatment HT 8.9%</strong>, control HT 8.7%**</td>
</tr>
<tr>
<td>Van Rosouw et al 1993</td>
<td>Reduction among men in SBP 4.5mmHg (5.8 to 5.2)<em>, DBP 2.3mmHg (1.9 to 2.7)</em>, among women SBP 6.3mmHg (5.7 to 6.9)<em>, DBP 3.4mmHg (3.0 to 3.8)</em> pre vs post</td>
<td>No data available</td>
<td>Reduction among men in BMI 0.1kg/ m2 (0.0 to 0.2), among women 0.5kg/m2 (0.4 to 0.6)*</td>
<td>No data available</td>
<td>No data available</td>
<td>Reduction among men in smoking 9.0% (7.0 to 8.0)<em>, among women 7.2% (6.8 to 7.7)</em></td>
<td>Increase among men in knowledge 7.5% (4.0 to 6.4)*</td>
</tr>
</tbody>
</table>
Table 2 (continued)

<table>
<thead>
<tr>
<th>Source</th>
<th>Blood pressure</th>
<th>Glucose/ HbA1c</th>
<th>Weight reduction</th>
<th>Physical activity</th>
<th>Diet</th>
<th>Smoking</th>
<th>Manage Risk Factor</th>
</tr>
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<tbody>
<tr>
<td>CSSS group 2007</td>
<td>Reduction SBP 5.4 mmHg (2.3 to 8.5)**, DBP 0.7 mmHg (0.5 to 1.9), pre vs post</td>
<td>No data available</td>
<td>No data available</td>
<td>No data available</td>
<td>No data available</td>
<td>No data available</td>
<td>No significant difference in treatment vs control, LTFU 2%</td>
</tr>
<tr>
<td>Gill et al 2008</td>
<td>No data available</td>
<td>Reduction in HbA1c 3.9%** pre vs post</td>
<td>Increase among men in BMI 2.2 kg/m²**, among women 1.3 kg/m²* pre vs post</td>
<td>No data available</td>
<td>No data available</td>
<td>No data available</td>
<td>LTFU 31%</td>
</tr>
<tr>
<td>Harati et al 2010</td>
<td>Reduction among men in SBP 3.2 mmHg (2.1 to 4.4)* and DBP 1.8 mmHg (0.6 to 3.0)<em>, among women SBP 1.1 mmHg (0.1 to 2.0)</em>, DBP 0.6 mmHg (0.03 to 1.2)*</td>
<td>Reduction among men in FBG 2.1 ml/dl (0.4 to 3.9)*, among women 2.3 mg/dl (1.0 to 3.7)**</td>
<td>Reduction among men in weight 0.5 kg (0.1 to 0.9)*, WC 0.2 cm (-0.6 to 1.0), among women weight 0.09 (-0.2 to 0.4), WC 1 cm (0.5 to 1.6)**</td>
<td>No data available</td>
<td>No data available</td>
<td>No data available</td>
<td>No data available</td>
</tr>
<tr>
<td>Source</td>
<td>Blood pressure</td>
<td>Glucose/ HbA1c</td>
<td>Weight reduction</td>
<td>Physical activity</td>
<td>Diet</td>
<td>Smoking</td>
<td>Manage Risk Factor</td>
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<td>-----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Isadikis et al 2011</td>
<td>Reduction in SBP 26mmHg**, DBP 14mmHg** pre vs post</td>
<td>No data available</td>
<td>No data available</td>
<td>No data available</td>
<td>No data available</td>
<td>No data available</td>
<td>Increase in control HT 36.5%* pre vs post, LTFU 42%</td>
</tr>
<tr>
<td>Jafar et al 2009</td>
<td>Reduction in SBP 10.8mmHg (8.9 to 12.8)**, DBP 4.7mmHg* pre vs post</td>
<td>No data available</td>
<td>No significant reduction in BMI</td>
<td>Increase in physical activity vs control group*</td>
<td>No data available</td>
<td>Reduction in smoking 2.8%** vs control</td>
<td>Increase in control of HT 29.6%** vs control, LTFU 22%</td>
</tr>
<tr>
<td>Kar et al 2008</td>
<td>Reduction in SBP 8.8mmHg** pre vs post</td>
<td>No data available</td>
<td>Reduction in weight 0.55kg</td>
<td>No data available</td>
<td>No data available</td>
<td>Increase of intention to quit smoking 49.0%** pre vs post</td>
<td>74.5% of referrals visit PHC, increase in control of HT 8.7%, increase in adherence 25.8%* pre vs post</td>
</tr>
<tr>
<td>Kengne et al 2009</td>
<td>Reduction in SBP 11.7mmHg (8.9 to 14.4)<strong>, DBP 7.8mmHg (5.9 to 9.7)</strong> pre vs post</td>
<td>Reduction in FPG 1.4mmol/L (0.6 to 2.6)* pre vs post</td>
<td>Reduction in weight 0.6kg (0.1 to 0.8)* pre vs post</td>
<td>No data available</td>
<td>No data available</td>
<td>No data available</td>
<td>LTFU 88%</td>
</tr>
<tr>
<td>Nguyen et al 2011</td>
<td>Reduction in SBP 29.2-55.5mmHg*, DBP 15.9-28.7mmHg*</td>
<td>No data available</td>
<td>No data available</td>
<td>No data available</td>
<td>No data available</td>
<td>No data available</td>
<td>LTFU 34%</td>
</tr>
</tbody>
</table>

**Note:** LTFU = Lost to Follow Up
<table>
<thead>
<tr>
<th>Source</th>
<th>Blood pressure</th>
<th>Glucose/HbA1c</th>
<th>Weight reduction</th>
<th>Physical activity</th>
<th>Diet</th>
<th>Smoking</th>
<th>Manage Risk Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onat et al 2003</td>
<td>Reduction SBP 26.0mmHg (0.1mmHg to 51.9mmHg)*</td>
<td>No data available</td>
<td>No data available</td>
<td>No data available</td>
<td>Reducing smoking 18.2%* pre vs post</td>
<td>LTFU 53%</td>
<td></td>
</tr>
<tr>
<td>Ramachandran et al 2006</td>
<td>No data available</td>
<td>15.5%* absolute risk reduction incidence DM vs control</td>
<td>No significant reduction in weight and WC</td>
<td>Increase physical activity 17.1%* pre vs post</td>
<td>Increase in healthy diet 19.1%* pre vs post</td>
<td>No data available</td>
<td>Increase in drug adherence 4.2% vs control, LTFU 4.9%</td>
</tr>
<tr>
<td>Salazar et al 2005</td>
<td>Reduction in SBP 5.5mmHg*, DBP 6.9mmHg* pre vs post</td>
<td>No data available</td>
<td>Reduction in weight 0.2kg</td>
<td>No data available</td>
<td>Reduction in alcohol intake 9.2g/week*</td>
<td>No data available</td>
<td>Increase in treatment 8.2%*</td>
</tr>
</tbody>
</table>

Explanation results: normal lettertype not significant, * p<0.05, ** p<0.001, between brackets ( to ) are the confidence intervals if available

Abbreviations: DBP-Diastolic Blood Pressure, DM-Diabetes Mellitus, FBG-Fasting Blood Glucose, HT-Hypertension, SBP-Systolic Blood Pressure, WC-Waist Circumference, LTFU-Lost to Follow up

1Adjusted for age, sex, locality, body mass index, 2Adjusted for age, ethnicity and interactions, 3Adjustment for age, 4Adjusted for age, sex, clustering, baseline SBP
abetes increased mostly in studies where health care staff was rigorously trained, and adherence improved in studies where follow-up appointments were given with relatively short intervals and reminders were sent to patients.

DISCUSSION

Several important insights have emerged from this systematic review of intervention studies to reduce the cardiovascular risk in LMICs. The reviewed studies were conducted on population level and on people with increased risk, and in urban as well as rural settings. There was a great variety of interventions with the four most prominent being: health promotion through media, health education, training health care staff and the implementation of guidelines for treatment. Additionally, some studies assessed adherence and cost-effectiveness of the interventions programs.

Health education and health promotion through media

Several studies showed that health education in combination with other interventions have a significant impact on population CVD health outcomes [18, 27, 34]. As a 2 mmHg reduction of blood pressure reduces death from strokes by 10%, it seems that these kinds of community interventions have a substantial public health benefit [43, 44]. On a patient level, Jafar et al. 2009 showed that a combination of health education towards patients’ households and training of general practitioners on management of hypertension has a strong impact on several important outcomes such as control of hypertension and reduction of mean blood pressure.

Other studies have also demonstrated a significant impact of health education on biomedical measurements such as HbA1c ([17, 28]. Huang et al. 2011 demonstrated an improvement in knowledge, behaviour and control of hypertension after an intervention of health education and training of health care providers. Knowledge on effects of risk factors and treatment approach more than doubled after the intervention. This might have resulted in sig-
significant reductions in salt and fatty products intake, pickled food and alcohol consumption as well as an increase in participation in physical exercise and increase in awareness, treatment and control of hypertension [41].

Similar to the results of the North Karelia study, the most significant lifestyle change in the current review was diet [45] with more than three quarters of the studies showing significant improvements.

The Isfahan Healthy Heart Program shows that in case of diet, the best results were seen in the change of using non-hydrogenated instead of hydrogenated oils and the reduction of salt intake [46]. Although diet is the most significant lifestyle change this is often not reflected in reduction of weight or waist circumference. Overweight and obesity seems to be the most challenging risk factors and as most of the studies showed no significant reduction.

There are promising results from the CSSS group (2007) and Cappuccio’s (2006) study on salt reduction and substitution in LMICs. The high salt intake in these settings is caused by personal use, in contrast to high salt intake due to consumption of processed foods in high income countries [3].

**Training of health care providers and implementation of treatment guidelines**

Various studies described the importance of intensive training of health care providers as the level of knowledge can be quite low in several health care settings [10, 47]. The studies that included training of health care providers in this review showed significant reductions in cardiovascular risk factors. Specifically in the studies that included task shifting, the training and supervision of health care providers was found to be essential. This review indicates that there are some promising results on task shifting of management of CVD risk factors from doctors to nurses [17, 25]. These have been supported by clear supervision and the development of guidelines. Implementing existing guidelines [29] or designing them for the specific location [17] also showed good results in the review. In the Cochrane study [48] on interventions
on hypertension control it is stated that there is a benefit if community-based clinics have an organised system of regular follow up and that medication should be given by means of a stepped care approach by implementing a structured guideline.

It is useful to link these trainings to a recognised medical organisation that gives the training better content and professional esteem. It is important to look not only for improvement at the public system, but also private practices as studies show that sometimes even more than half of the patients with cardiovascular risk factors visit the private sector in LMICs [29]. This review also shows that there is effective reduction of risk factors outside the health system, like on the worksite [18, 22].

The Cuban example shows that even in LMICs there can be high success rates of treatment and control of hypertension if there is a focus on primary health care, and that medication is easily available and affordable [49].

**Follow up and adherence**

Follow up and adherence remain key challenges in reduction of cardiovascular risk. Specifically, studies from Sub-Saharan Africa still have high rates of drop out like Kengne et al. 2009 in this review or smaller studies like Labhardt et al. 2011 [50], Bovet et al. 2008 [51] In all these studies the biggest loss to follow up was in the first three months after diagnosis and after community screening. Bovet argued that it is important to have a structured follow up after diagnosing hypertension as the majority of the patients (66%) failed to contact a clinic after the measurements. About 40% of these people stated that the main reason was that they lacked any symptoms, and about 15% mentioned treatment costs as barrier to adherence. Among the people that had visited a clinic, less than 10% were taking medication at the end of the year [51].

One of the successes of the study of Kar et al. 2008 might be due to the fact that they follow the patients closely in the first few months with scheduled visits at the clinic at first, third and fifth months, which is more often than most standard treatment guidelines recommend. The adherence increased from 35% to 61%
and the blood pressure decreased by 8 mmHg in the intervention group. Stricter follow up schedules may however worsen the strain on the already stretched health systems in LMICs. Kar et al. 2008, however, showed in the feasibility part of their study, that this intensive management of CVD might be integrated in the general health system. It took 13.6 minutes per person to do a risk assessment and they calculated that it is feasible to integrate screening in the package of the health care worker. Kar et al. 2008 demonstrated in the same study that there is a connection between availability of medication and adherence. As the availability of medication dropped at the public health facility, so did the adherence rate.

Some studies show that interventions are much more effective among older people who seem to be more adherent than younger people [30, 51]. The studies also show that the patients that tend to be more adherent are often highly educated, believe in the medication and have the support from their family [42]. Also comorbidity with diabetes show better results for follow up [35]. In Issa-kidis’s (2011) study the adherence of ART medication in the same clinic was 15 times higher than antihypertensive adherence, possibly due to inequality of care as HIV patients received free health care, money for transportation, food and social support, whereas the hypertension patients got nothing.

Feasibility

Some community studies like the national programme in Mauritius and the regional programmes in Iran, Indonesia, India, China and South Africa have demonstrated significant reductions in cardiovascular risk factors [24, 30, 32, 33, 38-40]. These studies have shown the effectiveness of comprehensive programmes in LMICs. The greatest challenge remains the political willingness of local authorities and the availability of resources to replicate and maintain support such programs in other LMICs. The initial programs have been supported to a large extent by WHO [32, 33, 38]. Because of relatively high costs and intensive support these programs might be challenging to sustain or scale up. Only a few studies have included in their study the costs [52, 53] and feasi-
bility [29]. The study of Jafar et al (2011) showed that a combination of patient education and training of general practitioners was the most cost-effective with 23 USD per 1.0 mmHg reduction in blood pressure among hypertensive patients. They measured the annual costs of their intervention at 3.99 USD per patient. Ramachandran et al (2006) came to the conclusion that medication and lifestyle advices are cost effective interventions for preventing diabetes among high-risk individuals.

As almost one billion people live today in urban slums and they are particularly at risk for cardiovascular diseases, it was striking that there were no large population studies from these settings. The same counts for the close to a billion people from Africa where only 5 of the 26 studies were taking place. In light of the fact that the urban population of SSA is predicted to triple in the next thirty years [54], there is a strong need to develop prevention programs for those people at risk, and specifically for the slum-dwellers who will continue to form the majority of urban populations on this continent.

Limitations

Literature reviews are prone to publication bias [55] and it is likely that studies with inconclusive or negative results might have been overlooked by publishers. Although we set a minimum of one year of follow up this is still a short period of time, which makes it difficult to generalise the outcomes to longer term periods.

As most of the studies have implemented a variety of interventions, it is difficult to determine which part of the intervention has been essential for the reduction of the cardiovascular risk factors. In order to understand the interaction between different parts of the intervention and the success of elements inside the intervention there should be more focus on process evaluation. Only one study [29] has elements of process evaluation by showing percentages of patients where the drugs were prescribed according to the protocol and measurements as per guideline were done.

The Isfahan study published a separate article on the process evaluation of the study, which gives more insight into the functioning of their intervention [56].
Less than half of the studies used a control group which makes it difficult to separate the outcomes from possible secular trend. Some studies [31] with control group show that interventions on BMI or waist circumference have only a modest difference before and after the implementation of the program but a significant difference with the control group. The main reason given for this finding according to the authors was the strong secular trend of rising rates of overweight and obesity. The rise of obesity versus reduction on other risk factors in the national programme in Mauritius shows how difficult it is to break this global trend.

Although we have tried to restrict our review to LMICs it is evident that there is still a great heterogeneity in the settings of these studies. For example, there is a big difference between a white South-African community [39] and a rural Cambodian community [35].

Additionally, because of limited resources, we restricted our literature search to only papers published in English. It is possible that the results of studies published in non-English languages may differ, which might affect our study conclusions. Furthermore, as the level of awareness and knowledge about CVD risk factors is still very low in LMICs it is easier to achieve positive findings on interventions with health education and health promotion through media [13]. This means that the effect of some interventions in this review might be reduced in the future when these countries develop and awareness will rise, but for now there is still a lot to gain.

**Key messages**

From this review it is clear that there have been effective community based programs to reduce cardiovascular risk factors in LMICs but that they are very limited, specifically to the urban poor where training of health care staff with guidelines proved to be effective. A key element of the intervention should be introducing treatment guidelines and training of health care providers. Health education for population and patients at risk with focus on diet and salt reduction is also important. Combining several interventions,
with an intensive follow up schedule and a community sensitive approach, that can be sustainable and scalable for LMICs are urgently required.

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