KaziBantu study protocol, version 11: 21/1/2019 (to be submitted to **BMC Public Health)**

Effects of a school-based health intervention programme in marginalised communities of Port Elizabeth, South Africa: the *KaziBantu* study protocol

Ivan Müller[1,2], Danielle Smith[3], Larissa Adams[3], Ann Aerts[4], Bruce P. Damons[5], Jan Degen[1], Stefanie Gall[1], Zaahira Gani[4], Markus Gerber[1], Annelie Gresse[6], Darelle van Greunen[7], Nandi Joubert[3], Tracey Marais[6], Siphesihle Nqweniso[3], Nicole Probst-Hensch[2,8], Rosa du Randt[3], Harald Seelig[1], Peter Steinmann[2,8], Jürg Utzinger[2,8], Christina Wadhwani[4], Cheryl Walter[3] and Uwe Pühse[1]

[1] *Department of Sport, Exercise and Health, University of Basel, St. Jakobsturm, Birsstrasse 320B, CH-4056 Basel, Switzerland*

[2] *Swiss Tropical and Public Health Institute, P.O. Box, CH-4002 Basel, Switzerland*

[3] *Department of Human Movement Science, Faculty of Health Sciences, Nelson Mandela University, P.O. Box 77000, Port Elizabeth 6031, South Africa*

[4] *Novartis Foundation, Novartis Campus, CH-4002 Basel, Switzerland*

[5] *Centre for the Community School, Faculty of Education, Nelson Mandela University, P.O. Box 77000, Port Elizabeth 6031, South Africa*

[6] *Department of Dietetics, Faculty of Health Sciences, Nelson Mandela University, P.O. Box 77000, Port Elizabeth 6031, South Africa*

[7] *Centre for Community Technologies, Faculty of Engineering, the Built Environment and Information Technology, Nelson Mandela University, P.O. Box 77000, Port Elizabeth 6031, South Africa*

[8] *University of Basel, P.O. Box, CH-4001 Basel, Switzerland*

***Corresponding author**

Uwe Pühse, Department of Sport, Exercise and Health, University of Basel, St. Jakob-Turm, Birsstrasse 320B, CH-4052 Basel, Switzerland

E-mail: uwe.puehse@unibas.ch, Tel.: +41 61 207-4784; Fax: +41 61 207-4789

E-mail addresses:

IM: ivan.mueller@unibas.ch

DS: danielle.smith@mandela.ac.za

LA: larissa.adams@mandela.ac.za

AA: ann.aerts@novartis.com

BPD: bruce.damons@mandela.ac.za

JD: jan.degen@unibas.ch

SG: stefanie.gall@unibas.ch

ZG: zaahira.gani@novartis.com

MG: markus.gerber@unibas.ch

AG: annelie.gresse@mandela.ac.za

DvG: darelle.vangreunen@mandela.ac.za

NJ: nandi.joubert@mandela.ac.za

TM: tracey.marais@gmail.com

SN: sihlenqweniso3@gmail.com

NP-H: nicole.probst@swisstph.ch

RdR: rosa.durandt@mandela.ac.za

HS: harald.seelig@unibas.ch

PS: peter.steinmann@swisstph.ch

JU: juerg.utzinger@swisstph.ch

CWad: christina.wadhwani@novartis.com

CWal: cheryl.walter@mandela.ac.za

UP: uwe.puehse@unibas.ch

Abstract

Background: The burden of poverty-related infectious diseases remains high in low- and middle-income countries, while non-communicable diseases are rapidly gaining importance. To countermeasure this dual disease burden, the *KaziBantu* project aims at improving and promoting health literacy as a means for a healthy and active lifestyle and builds on findings of the 'Disease, Activity and Schoolchildren's Health' (DASH) study. The project implements a school-based health intervention package, consisting of physical education, moving-to-music and health- and nutrition education lessons from the *KaziKidz* toolkit. It is complemented by the *KaziHealth* workplace health intervention programme for teachers.

Methods: A randomised controlled trial will be conducted in eight schools in Port Elizabeth, South Africa. Approximately 1,000 grade 4-6 schoolchildren, aged 9-13 years, and approximately 60 teachers will be recruited during a baseline survey in early 2019. For schoolchildren, the study is designed as a 9-month cluster-randomised controlled trial (*KaziKidz* intervention), while for teachers, a 6-month intervention phase (*KaziHealth* intervention) is planned. After randomisation, four of the eight schools will receive the education programme, while the other schools will serve as the control group. Intervention schools are further randomised to the different combinations of two additional intervention components, teacher workshops and teacher coaching.

Discussion: The *KaziKidz* teaching material is a holistic educational and instructional tool designed for primary school teachers in low-resource settings and it is in line with South Africa's Curriculum and Assessment Policy Statement (CAPS). The ready-to-use lessons and assessments within *KaziKidz* should facilitate the use and implementation of the teaching material. Furthermore, the *KaziHealth* interventions should empower teachers to take care of their health through knowledge gains regarding disease risk factors, physical activity, fitness, psychosocial health and nutrition indicators. Teachers as role models will be able to promote better health behaviours and encourage a healthy, active and inspiring environment for children at school. We conjecture that improved health and wellbeing increase teachers' productivity with trickle down effects on the children they teach and train.

Trial registration: www.isrctn.com; identifier: ISRCTN18485542 (date assigned: 11 July 2018).

Keywords: Anthropometry, Cardiovascular risk factors, Cognitive performance, Diabetes, Health interventions, Marginalised communities, Physical fitness, Physical activity, Schools, South Africa.

Background

Children's health and wellbeing is influenced by cultural, environmental and socioeconomic factors as well as living conditions and social and community networks (1). In low- and middle-income countries (LMICs), infectious diseases remain an important public health problem (2-4) with negative impacts on child development (5). Tens of millions of children are infected with parasitic worms (helminths) (6, 7). Chronic infections causing abdominal pain, diarrhoea and anaemia, and may impair cognitive and physical development (8), resulting in reduced fitness and work productivity (9). Additionally, helminth infections can negatively impact children's nutritional status (10).

While helminth infection and other neglected tropical diseases (NTDs) do not feature prominently on the burden of disease statistics of South Africa, some NTDs are common in disadvantaged populations, especially among children of poor communities. The nutritional status of schoolchildren from poor neighbourhoods is adversely affected by food outlets in close proximity to the schools. Indeed, many schoolchildren routinely purchase unhealthy foodstuff from local vendors and tuck shops that are generally low in nutritional value, often refined, processed and of low fibre content (11). In a 12-country study (Australia, Brazil, Canada, Colombia, Finland, India, Kenya, People's Republic of China, Portugal, South Africa, United Kingdom and United States of America) (12), South African children showed the highest intake of sugar sweetened beverages (13). Schools located in poor communities in South Africa are part of the National School Nutrition Programme, where members of the community are employed as food preparers. The food preparers do not have any food/nutrition related qualification and usually are unemployed parents from the community.

A deprived socioeconomic environment can put children at risk of malnutrition resulting in growth retardation. Malnutrition has been found to be associated with stunting and poor cognitive development resulting in a low intelligence quotient (IQ), cognitive delays and negative impact on motor development. This, in turn, negatively affects children's ability to concentrate, process information and focus on academic tasks. Children from low socioeconomic status (SES) families are also less likely to have access to health care or health insurance. Subsequently, this leads to a greater risk of illness, school absence and, ultimately, poor academic performance and life prospects. These deficiencies, caused mainly by the socioeconomic environment, can prevent school-aged children from realizing their full potential and perpetuate a vicious cycle of poverty and poor health.

Additionally, non-communicable diseases (NCDs) are a rapidly evolving public health problem worldwide, especially in LMICs, imposing a growing burden on population health (14, 15), including that of children (16). Urban African populations have moved towards a disease profile similar to Western countries, with increasing proportions of deaths attributed to chronic, lifestyle-related diseases (16). The co-existence of under- and over-nutrition has resulted in a double burden of nutrition-related diseases in Africa (17). Children may, already at a young age, develop risk factors predisposing them to NCDs in adulthood (18, 19). Hence, children are at risk of compromised health due to a dual burden of disease, which may hamper their development and wellbeing (2, 20). This dual burden constitutes a large and growing challenge for health systems in African countries.

With up to 80% of all heart disease, stroke and type 2 diabetes preventable through healthy nutrition and regular exercise, much more emphasis should be placed on prevention and awareness campaigns (21). Physical education (PE) plays a critical role in holistic health education of the child. Regular physical activity contributes to the development of physical competence and fitness, as well as to the cognitive, social and emotional development of the child. As a rule of thumb, children should undertake at least 60 min of moderate-to-vigorous physical activity (MVPA) daily.

The Healthy Active Kids South Africa Report Card (2018) has shown that many children, particularly from marginalised communities, do not achieve the minimal daily requirements of MVPA (13). Schools play an important role in making a meaningful contribution to the goal of achieving the recommended daily physical activity guidelines by incorporating PE lessons, amongst others, into the school curriculum. One plausible strategy to promote children's health is through school-based health promotion programmes. An attempt by a Swiss-South African research team to increase health literacy in South African children at school was the 'Disease, Activity and Schoolchildren's Health' (DASH) project (22). The study focused on grade 4 children and the creation of an enabling school environment. The intervention programme consisted of four main components, including (i) a medical examination and anthelminthic treatment; (ii) micronutrient supplementation in the form of a nutrient-dense paste enriched with protein, essential vitamins (vitamin A), minerals, energy and essential fatty acids; (iii) health education (e.g. hygiene and healthy nutrition); and (iv) physical activity (dancing and playful games). Our experiences with the DASH project also revealed that many South African teachers suffer from cardiovascular risk factors (23, 24). This insight was confirmed in a representative sample of South African educators (n=21,307) in public schools showing that educators reported considerably high stress levels, with

significant associations existing between stress, lack of job satisfaction and stress-related illnesses (25). In South Africa, NCDs have steadily increased. Indeed, while 42.9% of deaths in 2005 were attributable to NCDs, the proportion rose to 57.4% in 2016 (26). Furthermore, in 2017 more than 1.8 million cases of diabetes were recorded in South Africa, representing 5.4% of the adult population (27). The project 'Healthy Schools for Health Communities', presented here, addresses this dual burden of disease in both schoolchildren and teachers in South Africa (Figure 1).

Rationale

Having identified the potential for health status improvement among teachers and knowing the importance of teachers as role models in the education process of children, teachers will also participate in the proposed research project by involving them in a workplace health intervention. We will capitalize on the experiences from the aforementioned DASH project by scaling-up the intervention programme, and monitoring and improving the efficacy and effectiveness of the intervention programme. The goal of the *KaziBantu* project is to assess the impact of a school-based health intervention package on communicable diseases, risk factors for NCDs, health behaviours (beliefs and actions relating to health and wellbeing) and psychosocial health in primary schoolchildren in disadvantaged communities in Port Elizabeth, South Africa. Additionally, we aim to pilot test a workplace health intervention for teachers.

Methods

Study area

The study will be conducted in historically black and coloured primary schools in Port Elizabeth townships (Motherwell, Zwide, Kwazakhele and New Brighton) and northern areas (Schauderville, Bethelsdorp, Windvogel and Booysens Park), which form part of the Nelson Mandela Bay Municipality (Figure 2). These schools and communities are characterised by poverty and high unemployment rates. They represent the typical institutional and teacher-related PE barriers faced by the schools (28), including (i) shortage of qualified, accountable and engaged PE teachers; (ii) PE is marginalised as priority – it lost its standalone subject status in 1997 and is placed within the life skills/life orientation learning area, as more importance is given to other (examinable) subjects; (iii) teachers lack the ability to integrate PE with other study areas within the life skills/life orientation subject (personal and social

wellbeing, creative arts and PE); (iv) large class sizes; (v) insufficient and inadequate infrastructure and equipment; and (vi) safety and security challenges.

Study design

The intervention arm targeting schoolchildren is designed as a 9-month randomised controlled trial, including an intervention group (IG) (four schools) and a control group (CG) (four schools). The four intervention schools, assigned through randomisation, were further allocated randomly to the following intervention conditions: all schools will receive the teaching materials (*KaziKidz*/*KaziHealth*), but the components (i) workshop and (ii) coaching will be assigned as follows: (a) teaching materials only; (b) teaching materials plus workshops; (c) teaching materials plus coaching; and (d) teaching materials plus workshops plus coaching (Figure 3). The four remaining schools will be assigned to the CG. In the control schools there will be documentation of routine physical education and sports in school.

The primary comparison will be made between the four intervention schools and the four control schools; hence, assessing the benefit of teaching materials. Secondary comparisons will be teaching materials plus coaching vs. teaching materials without coaching or teaching materials plus workshop vs. teaching materials without workshop. In view of the factorial design of our study each comparison group consists of two schools.

By focusing on change in quantitative outcomes from baseline to follow-up, pre-existing differences between schools should play less of a role. While the intervention covers grades 1-7, in each school, one class each from grades 4, 5 and 6 will be randomly selected for evaluation of the intervention. After completion of the baseline assessment, children of the intervention schools will take part in a school-based health promotion programme (32 school weeks, one PE lesson of 40 min per week, one moving-to-music lesson of 40 min per week, three health education and three nutrition education lessons of 40 min per year across the whole study period). The follow-up is after 9 months (Figure 4). Qualitative data on the feasibility and acceptability of the intervention measures will also be collected from teachers through focus group discussions (FGDs).

For teachers, the study is designed as a 20-week randomised controlled trial (Figure 5). The baseline assessment will also be offered to the teachers in the control schools. Intervention schools are randomly assigned to the four different combinations of the additional components. After completion of the baseline assessment, all teachers will be

informed about their personal health profile, providing an overview of cardiovascular health markers and mental health parameters. For each parameter, established internationally accepted cut-off and normative values will be used to estimate teachers' health risks.

The intervention programme consists of three main components:

(i) ***KaziKidz* and *KaziHealth* teaching material.** It is a holistic education and instructional tool designed for primary school teachers. This teaching material was pilot tested at two elementary schools in the Port Elizabeth area in August 2018. Feedback from teachers was obtained and the material revised and finalised. Through the implementation of three content pillars – (a) PE; (b) moving-to-music; and (c) health and hygiene and nutrition education lessons – the toolkit aims to enhance children's overall health in disadvantaged South African primary schools. The *KaziKidz* teaching material consists of lesson plans within each of the three content pillars. The lessons have been designed in line with the South Africa's Curriculum and Assessment Policy Statement (CAPS). Ready-to-use assessments can be found at the end of each section, which may be integrated into formal assessments of children's performance and can complement the school academic curricula. The purpose is to lead children through content, games and activities, partly supported by music, and conducted in a joyful manner that encourages and promotes a healthy lifestyle throughout childhood into adolescence. *Kazi* (an animated active mascot, designed to encourage children to participate in *KaziKidz*) and lesson plans will guide teachers through the teaching material. We expect that by using the *KaziKidz* teaching material, teachers contribute to further the health and wellbeing of the children they teach and educate.

   i) Physical activity: regular physical activity opportunities (one PE lesson of 40 min per week), will be incorporated into the main school curriculum in grades 1-7 over 32 weeks of the school year. A physical activity friendly school environment will be created. These interventions are designed towards improving children's physical activity levels and positively affecting their psychosocial wellbeing.

   ii) The moving-to-music classes have been designed to promote physical activity through song and dance. Weekly lessons of 40 min each are designed with easy-to-follow illustrations that allow teachers to instruct without participating physically in the lessons. Schools or teachers that have a sound system available, can make use of movement songs that have been created with cues specifically tailored to the lessons. Options for creating music through drums or any other form of percussion

or clapping hands are also provided. Within the lessons, direct speech is used to address the children for easy application (29).

iii) Health, hygiene and nutrition education: a series of classroom-based lessons have been developed. Schoolchildren will be educated on intestinal parasite prevention and treatment, such as proper hygiene, sanitation habits and the importance of consuming clean water and food. By addressing these factors and educating children about appropriate health and hygiene behaviours, both the teachers and the schoolchildren are at a reduced risk of infection. Another series of classroom-based lessons will help to increase awareness for the importance of healthy nutrition. The South African National School Nutrition Programme (NSNP) attempts to address micronutrient deficiencies and alleviate short-term hunger by providing food that supplies at least 30% of the daily energy requirements of a child. In order to complement this, the nutrition education lessons (3 x 40 min lessons per grade for grades 1-7) should bring dietetics closer to the learners in a playful way and encourage sustainable healthy eating habits throughout the learners' lives. In addition, an analysis of the school feeding programme will be done to identify ways to improve their current diet. The food preparers in schools will also be trained in basic nutrition and hygiene during preparation of the school meals as unhygienic circumstances and poorly prepared meals can lead to infections and low nutrient intake (30).

KaziHealth is a workplace health promotion programme that aims to educate and improve health behaviours among teachers. The programme starts with an individualised health risk assessment, followed by face-to-face lifestyle coaching sessions and self-monitoring and motivation through the *KaziHealth* mobile application. All teachers willing to participate in the programme will undergo a comprehensive health risk assessment. Additionally, teachers of the intervention schools will have the option to participate in a 20-week workplace health promotion programme (Figure 6).

(ii) **Workshops:** Teachers of two schools will participate in workshops for both *KaziKidz* and *KaziHealth.* The teaching content (lessons and assessments) of *KaziKidz* will be explained to the teachers prior to the implementation of the teaching material (2 sessions of 90 min each, as well as practical demonstrations and instruction at schools). For *KaziHealth,* individually tailored lifestyle coaching workshops (2 sessions of 90 min each). The workshops will be relatively small (maximum of 20 teachers per workshop) and led by health professionals specialising in physical

activity promotion, diet, nutrition and psychosocial health. Furthermore, education, motivation and self-monitoring will be provided through the *KaziHealth* mobile application (29) to assist individuals in making healthier lifestyle choices and decrease health risks. The *KaziHealth* mobile application (29) integrates three lifestyle interventions; namely, physical activity, nutrition and stress management, in order to guide individuals in achieving personal health goals. To test the efficacy of the workplace health promotion programme over time, teachers will be assessed a second time after 20 weeks.

(iii)**Teacher coaches:** In the two schools where teachers are offered coaching, trained sports students from the Department of Human Movement Science at the Nelson Mandela University, will act as teacher coaches assisting the teachers in teaching and ensuring that the intervention is implemented in the schools correctly and as intensively as planned. Furthermore, they will also monitor the intervention process.

Sample size and randomisation

Assuming that the prevalence of obesity varies across schools according to a log-normal distribution with a mean value of 3% and a standard deviation of 2%, 125 children per school in each of the eight schools would provide a prevalence estimate between 1.5% and 5% with a probability of 95%. Under this assumption, 95% of school-specific prevalences would range between 0.8% and 8.2%. Hence, our aim is to recruit 125 children per school.

The power calculation for the intervention study is based on the change in a quantitative outcome variable from baseline to follow-up. We denote the standard deviation of its change across schools and children by σ. Assuming an intervention effect size of $0.5 \times \sigma$ and an intraclass correlation of 0.04 for the clustering of individual changes within schools (corresponding to a random effect standard deviation of $0.2 \times \sigma$), 400 children in the four intervention schools (i.e. 100 children per school) participating in baseline and follow-up, and 400 children in the four control schools would provide over 85% power to observe a statistically significant difference in the mean change of the respective outcome variable between intervention and control schools at the 5%-level.

Enrolment of schools will be done by the local research team. In order not to contaminate intervention effects, schools rather than classes will be randomised in January 2019. Before randomisation schools will be divided into two geographical groups, namely township areas and northern areas, each containing four schools. Township areas are predominantly inhabited

by black Africans and northern areas by coloured people (after an Apartheid-era classification which refers to people from a multiracial ethnic background and can include persons of Khoi and San origin). The randomisation into intervention and control schools will be done separately in each of the two groups so that each group is assigned two intervention and two control schools. To keep the design as balanced as possible, the four intervention schemes (i.e. teaching materials only; teaching materials plus teacher workshops; teaching materials plus teacher coaching; and teaching materials plus teacher workshops plus teacher coaching) will be assigned in such a way that the intervention schools of one group will get teaching materials plus either teacher workshops or teacher coaching and those of the other groups. Randomisation will allow to determine which of the two groups gets which of the two pairs of intervention schemes. Sequentially numbered, opaque sealed envelopes (SNOSE) will be used for the assignment of the intervention arms to the schools.

Study participants

The impact of the *KaziKidz* teaching material will be evaluated in one randomly selected class in grades 4, 5 and 6 (= intermediate phase) in each of the eight study schools (interventions are randomly assigned to any of the four northern area or four township schools) even though *KaziKidz* teaching material will be offered to all classes in grades 1-7 as part of the life skills/life orientation courses in the school curriculum.

For *KaziHealth*, all teachers at the eight schools will be invited to participate in the programme. All participating teachers will undergo the full health risk assessment, and teachers at the intervention schools will have the option to participate in the 20-week intervention. The teachers at the control schools will be offered the intervention programme after the completion of the study.

School selection, participant recruitment and written informed consent

South African public schools are classified into five groups, with quintile five representing the least poor and quintile one representing the poorest. The quintiles are determined through the national poverty table, developed by the treasury (31). Areas are being ranked on the basis of income levels, dependency ratios and literacy rates in the area. The quintile ranking of a school determines the no-fee status of the school and the amount of money that a school receives from the government, with the poorest schools receiving the greatest per-child

allocation. Approximately 200 principals and/or representatives from 349 quintile 3 primary schools (no-fee paying schools) of the Nelson Mandela Bay Municipality attended information sharing sessions at the Eastern Cape Department of Education (ECDoE) in October 2018. The intention was to be inclusive and invite as many interested principals as possible to inform them of the study. A total of 64 responses were received from interested schools; however, only eight of the responses (representative of typical quintile 3 primary schools) matched the following study criteria:

(i) Geographical location and representation of the target communities: 'township areas', inhabited predominantly by black African people and the 'northern areas', inhabited by predominantly coloured people; both these communities needed to be represented equally.

(ii) Spoken language (IsiXhosa, Afrikaans or English).

(iii)Commitment by school principal to support the project activities.

The school authorities will be informed about the project and asked for their interest and consent. Interested schools will be visited, and the investigators will consult with the school administrators to find out if the school environment is conducive to conducting the study. Principals and teachers from selected schools will be informed about the objectives, procedures and potential risks and benefits of the study. Teachers, children and parents/guardians will be informed, and teachers and children invited to participate in the study. Prior to enrolment, a participant information sheet will be provided in English, IsiXhosa or Afrikaans (local languages) to all potential participants and in the case of the children, their parents/guardians. For the evaluation part of the study, oral assent of each participating child will be obtained, while written informed consent will be obtained from parents/guardians and teachers. Participation is voluntary, and hence, children and teachers can withdraw anytime without consequences or further obligations.

Potential participants will be enrolled in the project for evaluation purposes if they meet the following inclusion criteria: (i) are willing to participate in the study; (ii) have a written informed consent (for children by a parent/guardian); (iii) are not participating in other clinical trials during the study period; and (iv) do not suffer from severe medical conditions, as determined by qualified medical personnel. Approximately 1000 grade 4-6 schoolchildren, aged around 9-13 years, and approximately 60 teachers from eight primary schools will be recruited during the *KaziBantu* baseline survey in early 2019.

Assessment methods

Primary outcomes for the *KaziKidz* testing battery include: (i) anthropometric and clinical examinations; (ii) physical fitness and self-reported and objectively assessed activity; (iii) cognitive and academic performance; and (iv) questionnaires for assessment of psychosocial health. Primary outcomes for the *KaziHealth* testing battery include: (i) anthropometric and body composition assessments; (ii) clinical examinations; (iii) self-reported and objectively assessed physical activity and physical fitness; and (iv) questionnaires for assessment of psychosocial health. Further measures include diet and nutritional analysis with the 24-hour dietary recall. Secondary outcomes for both testings' are gender, ethnicity, SES, age, weight and height. Figure 7 summarises the assessment methods to be utilised in this study. For baseline and follow-up survey, the same scientifically recognised procedures are selected and will be conducted by professional staff, adhering to standardised, quality-controlled protocols.

KaziKidz **assessment protocol**

Anthropometric measurements

(i) From each participant, body weight and height will be measured by standing on a digital weighing scale and against a stadiometer with back erect and shoulders relaxed, recorded to the nearest 0.1 kg and to the nearest 0.1 cm, respectively. Age- and gender-specific height or height-for-age and weight-for-age z-scores will be calculated from the current CDC/WHO growth reference data. Body mass index (BMI) and specific z-scores will be calculated as follows: (i) BMI = weight (kg) / height $(m)^2$; (ii) BMI for children older than 5 years (BMIZ), an indicator for weight-for-height proportion (WHO growth reference for children older than 60 months) (20); (iii) height-for-age (HAZ), an indicator of growth disorders (WHO growth reference for children older than 60 months); and (iv) weight-for-age (WAZ).

(ii) A measuring tape will be used to determine the waist circumference of the participant at the natural waist (midway between the ribcage and the iliac crest). After measuring the hip circumference, the waist-to-hip ratio will be calculated, a risk indicator for heart disease (i.e. the smaller the waist in comparison to the hips, the lower the risk of heart disease) (32).

Questionnaires

To gather information on children's social and demographic background, SES, self-perceived stress, school satisfaction, academic self-concept, self-reported physical activity behaviour and general health status, the following questionnaires will be applied:

(i) Demographic data and SES of each participant will be determined.

(ii) The KIDSCREEN-10 will be implemented to determine children's physical and psychological wellbeing, moods and emotions, self-awareness, autonomy, parenting and family life, financial resources, peers and social support, school environment and bullying. The questionnaire comprises of 10 points and has proven to be a valid tool for assessing the psychosocial health of children aged 8-18 years (33-35).

(iii) Three items from the Health Behaviour in School-aged Children (HBSC) survey (36) will be used to assess individual perceived stress, school satisfaction and academic self-concept. Learners will be asked how they perceive the pressure, including from homework, related to school (37). To estimate school satisfaction, children will be asked to respond to the question: 'How do you feel about school at present?'.

(iv) Children will also be asked questions about their physical activity behaviour, including: sports participation, being physically active during school hours and type of play during school hours and in their free time. Information will be collected over a 7-day period. The questions are adjusted using the Physical Activity Questionnaire for Children (PAQ-C), an instrument used to gain insights into general levels of physical activity throughout the elementary school year for children attending grades 4-8, aged between 8 and 14 years (38).

Clinical examinations

(i) The children's health review will include a detailed history and physical examination. Self-reported health status will focus on intestinal symptoms, including abdominal pain and changes in bowel movements. Additionally, we will assess children's evolution of cognitive and physical development. The physical examination is directed towards evidence of anaemia (e.g. conjunctival pallor), abdominal conditions (e.g. hepatomegaly and splenomegaly) and evidence of pulmonary hypertension (e.g. jugulovenous pressure and cardiac auscultation).

(ii) Regarding high blood pressure detection, each participant's blood pressure will be measured three times after the participant has been seated for 5 min with a calibrated Omron® digital blood pressure monitor (Omron® M6 AC model; Hoofddorp, The

Netherlands). The cuff is wrapped around the left arm so that only a finger can fit between the cuff and arm. The bottom of the cuff is placed about 4 cm above the elbow with the palm facing up, while the blood pressure is taken. For children, a cuff size of 17-22 cm will be used (Omron® CS2 Small Cuff; Hoofddorp, The Netherlands). Since the first measurement often results in higher values, the average of the second and third measurements will be utilized to estimate systolic and diastolic blood pressure. To analyse the data, children will be categorised into a normotensive, pre-hypertensive or hypertensive group, based on percentiles, taking into account the age, sex and height of the children (normotensive: $<90^{th}$ percentile; pre-hypertensive: $\geq 90^{th}$ to $<95^{th}$ percentile; and hypertensive: $\geq 95^{th}$ percentile).

(iii) For determination of the full blood lipid profile (total cholesterol [TC], low-density lipoprotein cholesterol [LDL-C], high-density lipoprotein cholesterol [HDL-C], triglycerides [TG], non-HDL cholesterol [non-HDL] and cholesterol high-density lipoprotein ratio [C-HDL ratio]) and glycated haemoglobin (HbA1c) affecting diabetes, a point-of-care (POC) instrument (Alere Afinion AS 100 Analyzer, Abbott Technologies; Abbott Park, United States of America) will be used, providing results within a 8 min. The HbA1c level reflects the average plasma glucose concentration levels over the last 8-12 weeks. After the participant's fingertip is cleaned with an alcohol swab, a nurse will prick the fingertip with a safety lancet and gently squeeze out two drops of blood. The first drop will be wiped away and the second drop will be collected for analysis. Before the testing, all machines are tested and calibrated with controls.

Physical fitness tests

For the purpose of this study, selected tests from the Eurofit fitness battery (39) will be utilized.

(i) Cardiorespiratory fitness of children will be measured with the 20 m shuttle run test by Léger *et al.* (40). In brief, a 20 m flat course, measured by tape and marked with cones, will serve for the test. Ten tracks are set. The pre-recorded sound signals are played to the children and they are prompted for the test run in two intervals (2 x 20 m). Once the children are familiar with the test procedures, they are asked to run back and forth in groups of 10, following the pre-set pace of the sound signals. Starting at a speed of 8.5 km/h, the frequency of the signal is gradually increased so that the speed increases by 0.5 km/h from one minute to the other. If children cannot follow the signal, and do not reach the 20 m line for two consecutive intervals, they will be asked to stop the test, and the

distance travelled (in full laps) will be recorded. To calculate cardiorespiratory fitness, the number of laps is converted to a speed value, and along with the participant's age, used in the formula provided by Léger *et al.* (40) to estimate VO_2 max (ml x kg^{-1} x min^{-1}).

(ii) Upper body strength will be determined using the handgrip resistance test, which measures the maximum isometric force that can be generated primarily by the hand muscles. The field investigator will demonstrate how to grip the dynamometer. Each participant will have one preliminary trial per hand (with a 30 sec rest in between) to grip the dynamometer as hard as possible. Additionally, the dominant hand will be noted. The participant remains in a standard bipedal pose with their shoulder adducted and neutrally rotated, elbow flexed at 90 degrees, forearm in neutral position holding the Saehan hydraulic dynamometer (MSD Europe BVBA; Tisselt, Belgium) without making contact with any body part. The dynamometer is adapted to hand size of each participant and the maximum readings of six trials (measured to the nearest 0.5 kg, three trials per hand) will be recorded. The highest score is used as the final result. Higher values indicate better performance.

Objective activity measurements

(i) Physical activity behaviour will be assessed with an ActiGraph wGT3X-BT accelerometer (41). Participants are instructed to wear the device at all times (except during activities involving water contact) for 7 days around the hip. The measured period includes 5 school days and 2 weekend days. Devices are running on the most recent firmware version (v. 1.9.2 at the time of writing the current piece) and are initialized at a sampling rate of 30 Hz.

Cognitive performance

(i) In cooperation with the schools, the school exam grades for the following subjects will be obtained: English, maths, home language and life skills. The sum score of these four subjects will be used to estimate the academic achievements.

(ii) Additionally, we will obtain school schedules to monitor the overall academic progress of the children. A school schedule is a quarterly summative tool used by schools to measure and track the progress of the learners, across all their subjects, in an academic year. In addition to tracking the child's progress in the grade, the school schedule is used at the end of the academic year to determine whether the child will proceed to the next grade or to retain the child in the present grade.

KaziHealth assessment protocol

At baseline and follow-up testing, a comprehensive health risk assessment by healthcare personnel will be performed on participating teachers via the *KaziCHAT*, a Comprehensive Health Assessment Tool, which will be used to capture and interpret all assessed health parameters. Internationally accepted cut-off and normative values will be used to rate each tested parameter based on a traffic light model. A personal health risk profile will be generated, with easy to understand explanations of the tested parameters, as well as further referrals to a general practitioner, if needed.

Anthropometry and body composition

(i) Utilising the same protocol as for *KaziKidz*, each participant's body weight and height will be measured to calculate the BMI.

(ii) Utilising the same protocol as for *KaziKidz*, waist and hip circumferences will be measured to determine waist-to-hip ratio, a risk indicator for heart disease (32).

(iii) Bone mineral density and body fat percentage will be measured with the Discovery Hologic Dual-Energy X-ray Absorptiometry (DXA) QDR 4500A (APEX System Software Version 4.0.2) by a qualified radiographer. Pregnant individuals, individuals who underwent investigations using radioisotopes in the previous 10 days, and individuals with internal metal artefacts will be excluded from the DXA scan. Calibration will be conducted prior to testing, using the quality check (QC) test. Participant's height, weight, age, gender, birthdate and ethnicity will be entered before the participant will be instructed to lay supine on an open X-ray table within specified position boundaries. The participant will be instructed to lay still and breathe normally, while the scan is being conducted, a process that takes approximately 7.5 min.

Clinical measures

(i) A detailed family and medical history will be taken from each participant by a healthcare professional. Present and previous signs or symptoms of cardiac disease (e.g. myocardial infarction, palpitations and arrhythmias), non-communicable diseases (e.g. hypertension, dyslipidaemia and diabetes) and psychological conditions (e.g. headaches, sleep disorders and depression) will be recorded. The Physical Activity Readiness Questionnaire (PAR-Q) will be used to determine whether medical clearance from a general practitioner will be required prior to the physical fitness assessment (42).

(ii) Each participant's blood pressure will be measured three times after the participant has been seated for 5 min with a calibrated Omron® digital blood pressure monitor (Omron® M6 AC model; Hoofddorp, The Netherlands) for the detection of prehypertension and hypertension. A medium or large adult cuff size, 22-32 cm or 32-42 cm, respectively (Omron® Medium and Large Cuff; Hoofddorp, The Netherlands) will be used depending on the participant's arm circumference. The same protocol as indicated for *KaziKidz*, will be followed to determine the final systolic and diastolic blood pressure values.

(iii) Dyslipidaemia and glycosylated haemoglobin will be tested with a POC instrument (Alere Afinion AS 100 Analyzer, Abbott Technologies; Abbott Park, United States of America), using a full lipid profile (TC, LDL-C, HDL-C, TG, non-HDL and C-HDL ratio) and HbA1c test, respectively. The same protocol used for *KaziKidz* in this regard will also be applied for assessing these variables.

(iv) For the detection of anaemia, the haemoglobin concentration will be measured to the nearest 0.1 g/l, using a HemoCue® Hb 301 system (HemoCue®AB; Ängelholm, Sweden). The Eurotrol Hb 301 Control will be used to verify the precision and accuracy of the measuring device.

Physical activity and physical fitness

(i) Using the same protocol as for *KaziKidz*, physical activity behaviour will be assessed with accelerometry.

(ii) Cardiorespiratory fitness will be assessed through the Cooper 12 min run-walk test. The test is a simple, self-paced, maximal running test that is used to determine an individual's maximal oxygen uptake (VO_2 max). The aim of the test is to run or walk as far as possible within 12 min. VO_2 max is then calculated with the following formula:

$$VO_2 \text{ max} \,(\text{ml x kg}^{-1} \text{ x min}^{-1}) = \frac{d_{12} + 504.9}{44.73}$$

Where d_{12} refers to the total distance covered in 12 min in metres (43). Before the test starts, blood pressure and heart rate are measured, and a 10-min warm up period is given. All participants will receive the same instructions and no verbal encouragement is allowed throughout the test. After the test is completed, a 5-min cool down period will be given. Although all possible measures will be taken to reduce risk, all maximum exercise tests involve some risk. The test will be supervised by trained healthcare professionals with the necessary knowledge to deal with any medical emergency that may arise. Furthermore, an automated external defibrillator (AED) will be available on site.

(iii) Upper body strength will be determined with the handgrip resistance test utilising the same procedure as described in the *KaziKidz* protocol.

Psychosocial health questionnaires

To gather information about the demographic profile and SES, health behaviours and psychosocial health indicators of each participant, the following will be completed by each participant by means of a questionnaire survey.

(i) Demographic data and SES determined through household income and assets (property and car ownership).

(ii) Cigarette smoking, alcohol use and screen time per day.

(iii) Subjective perceived health measured with two items from the 12-item short form health survey (SF-12), adapted from the SF-36. Participants will be asked to rate the following questions: 'In general, would you say your health is?' and 'How motivated are you to improve your lifestyle?'.

(iv) Work related stress will be assessed using the short version of the original Effort-Reward Imbalance (ERI) questionnaire (44).

(v) The Shirom–Melamed Burnout Measure (SMBM), a validated and widely used tool, will be used to assess occupational burnout (45).

(vi) Diet and nutritional analysis with a 24-hour dietary recall.

(vii) The General Health Questionnaire (GHQ-12) will assess mental distress or minor psychiatric morbidities.

(viii) Subjective sleep complaints will be assessed utilising the brief 7-item self-report Insomnia Severity Index (ISI) (46).

Data collection and statistical analysis

The following data will be collected: (i) quantitative data on blood pressure, glycated haemoglobin and blood lipids, anthropometry and levels of physical fitness, cognitive performance and psychosocial health; (ii) SES and demographic data; and (iii) qualitative data on the feasibility and acceptability of the intervention measures implemented through focus group discussions. Quantitative data will be entered twice and cross-checked using EpiData version 3.1 (EpiData Association; Odense, Denmark). Cleaned data will be transferred to STATA version 13.0 (STATA Corp., College Station, TX, USA). Questionnaire data will be

collected using the software package EvaSys (Survey Automation Suite, version 7.1) and analysed with STATA.

Clinical and anthropometric indicators, physical fitness, cognitive performance and psychosocial health values will be summarized by their mean and standard deviation at normal distribution, and otherwise by their median and interquartile ranges. Questionnaire information on psychosocial health will be expressed as a percentage.

For the analysis of cross-sectional and longitudinal associations, mixed linear or mixed logistic regression models will be used, depending on the type of outcome variable. These models will be adjusted for clustering within classes and schools using random intercepts. In analyses of cross-sectional associations, the models will include personal characteristics of children, such as gender and age, SES of parents/guardians and other potential confounders of the associations of interest. Models assessing intervention effects will additionally include three indicator variables, as defined at the level of schools, one for schools of the intervention arm, one for schools receiving teacher workshops and one for schools receiving teacher coaching. In addition, these models may include the value of the respective outcome variable at baseline. Since intervention effects may also depend on the child's initial characteristics, stratified analyses and analyses with interaction terms will be performed. Potential effect modifiers tested include gender, age, SES, ethnicity, health status and physical fitness at the baseline test.

The primary objectives of the statistical analyses are: (i) to assess the physical fitness of the participants and their associations with cognitive performance and psychosocial health at the beginning and over the course of the intervention; and (ii) the impact of interventions on disease status and other health parameters. The secondary objective is to assess the feasibility and acceptability of the health interventions, as determined by focus group discussions.

Ethical approval and considerations

Ethical approval for the study has been received from the following ethics committees in Port Elizabeth, South Africa: (i) The Nelson Mandela University Ethics Committee (reference no. H18-HEA-HMS-001; obtained on 26 March 2018); (ii) Eastern Cape Department of Education (obtained on 9 May 2018); and (iii) Eastern Cape Department of Health (reference no. EC_201804_007; obtained on 5 June 2018). The study is registered at the ethical review board of Northwestern and Central Switzerland (EKNZ) (reference no. R-2018-00047; registered on 1 March 2018).

The investigators will explain to each participant (children and teachers) the nature of the study, the purpose, procedures involved, the expected duration, and potential risks and benefits it may entail. Each participant will be informed that participation is voluntary, and hence, participants can withdraw anytime without any further obligations. All participants will be provided with an information sheet and a consent form describing the study. Individual medical information obtained as a result of this study will be considered confidential. Subject confidentiality will be ensured by utilizing subject identification code numbers to correspond to treatment data in password-protected computer files. For data verification purposes, authorised representatives of the EKNZ and the Nelson Mandela University Human Ethics Committee may require direct access to parts of the clinical records relevant to the study, including participants' medical history. At the end of the study, the results will be communicated to the Department of Health and the Department of Education in Port Elizabeth, as well as the involved schools. All intervention materials will be made available to the control schools after completion of the study so that the whole school community can benefit from this project. Workshops will be offered to the control schools to prepare teachers to implement the *KaziKidz* teaching material. Furthermore, teachers of the control schools will have the possibility to take part in the workplace health promotion intervention programme after the completion of the second health assessment.

Discussion

Results from the DASH study revealed that the prevalence of soil-transmitted helminth infection among grade 4 children was above 60% in several schools in Port Elizabeth (47). Moreover, infected children had lower VO_2 max compared to their non-infected peers (47); helminth infections and low physical fitness were significant predictors of low selective attention and poor academic achievement (48); physical activity was associated with health-related quality of life (49); almost one third of all schoolchildren were classified as hypertensive (50); and the physical activity intervention component contributed to the maintenance of academic performance (51) and resulted in a significantly delayed increase in children's BMI (52). Importantly, the DASH intervention package was well received in all schools.

The *KaziBantu* project is a logical continuation of the DASH project and aims at contributing to healthy schools and healthy communities. Teachers as leaders in communities have an important role to play in this regard. We conjecture that teachers as healthy role

models will be able to promote better health behaviours and encourage a healthy, active and inspiring environment for learners and peers at school. Various health professionals will empower teachers with specific knowledge related to infectious and non-communicable disease risk factors, physical activity and fitness, psychosocial health and nutrition. Improved health and wellbeing increases teachers' productivity, benefitting their own health and wellbeing and that of the children they teach and educate. We hypothesis that implementing *KaziBantu* will result in less absenteeism, a reduction in stress and better coping with work demands.

Pursuing the current study protocol will provide specific answers to the following questions: Are *KaziKidz* teaching materials useful? What are difficulties in using the teaching materials from the perspective of the teachers? How do the teachers experience the coaching by the teacher coaches? What experiences do the coaches have in their work with the teachers? What attitudes do teachers have with regard to the lessons proposed? What are the conditions for an effective and sustainable implementation of this teaching material? Does the acceptance of the *KaziKidz* teaching material by the teachers moderate its effectiveness?

Regarding the implementation of *KaziKidz* and *KaziHealth*, three languages are spoken by the communities in the study area; namely, Afrikaans, IsiXhosa and English. To ensure comprehension, translated questionnaires into the local languages have been pre-tested by native speakers, with an emphasis on those that focus on mental health indicators to match the educational attainment of children and help them to understand and answer the questions. The study will be conducted in impoverished and harsh environments where illiteracy, neglect and violence are common (53, 54), which might impact on the granting of informed consent by parents and guardians. For illiterate parents/guardian, a literate witness will be invited to sign, while participants will be asked to provide a thumbprint. To ensure return of the signed consent forms, we might ask potential study participants several times. Specific safety procedures are in place to conduce the research. While it is difficult to predict the extent of people's mobility and movement, we anticipate a substantial loss to follow-up as people show considerable mobility in this setting. Multiple imputation will be used to deal with missing data where appropriate.

Taken together, the *KaziBantu* project builds upon the DASH project and aims to improve physical health and wellbeing, cognitive performance and psychosocial and clinical health of children and teachers. The South African Department of Education seeks to create a lifelong learner who is confident and independent, literate, numerate and multi-skilled, compassionate, with a respect for the environment and the ability to participate in society as

an active citizen. The Education Department also envisions healthy teachers who are qualified, competent, dedicated and caring and who will be able to fulfil the various roles of an educator. Hence, the project aspires to assist the Education Department by contributing to the development of the full potential of each learner and the transformation of education in South Africa. In addition, developed and validated *KaziKidz* workshop material may be translated into short learning programmes for accreditation of Teachers' Continued Professional Development. The *KaziChat* application will be made available to the Education Department's Directorate responsible for human resources for distribution to all teachers together with encouragement for implementation. This study builds on local evidence and offers the possibility of providing new evidence on health intervention responses to non-communicable disease risk factors as a basis for future controlled studies that will enable comparisons amongst marginalised communities between South Africa and other African countries.

List of abbreviations

AED	Automated external defibrillator
BMIZ	Body mass index z-score
CAPS	Curriculum and assessment policy statement
CDC	Centers for disease control and prevention
DASH	Disease, activity and schoolchildren's health
DXA	Discovery hologic dual-energy x-ray absorptiometry
ECDoE	Eastern cape department of education
EKNZ	Northwestern and central Switzerland
ERI	Effort-reward imbalance questionnaire
FGDs	Focus group discussions
GHQ-12	General health questionnaire
HAZ	Height for age z-score
HBSC	Health behaviour in school-aged children
HDL-C	High-density lipoprotein cholesterol
ISI	Insomnia severity index
ISRCTN	International standard randomised controlled trial number
KaziCHAT	Comprehensive health assessment tool
KaziHealth	School teachers' health intervention

KaziKidz	Schoolchildren's health intervention
LDL-C	Low-density lipoprotein cholesterol
LTMICs	Low- to middle-income countries
MVPA	Moderate-to-vigorous intensity physical activity
NCDs	Non-communicable diseases
non-HDL	Non-high density lipoprotein cholesterol
NRF	National research foundation
NSNP	National school nutrition programme
NTDs	Neglected tropical diseases
PAQ-C	Physical activity questionnaire for children
PAR-Q	Physical activity readiness questionnaire
PE	Physical education
POC	Point-of-care
SES	Socioeconomic status
SF-12	Short form health survey
SMBM	Shirom–Melamed burnout measure
SNOSE	Sequentially numbered, opaque sealed envelopes
SNSF	Swiss national science foundation
SSAJRP	Swiss South African joint research programme
TC	Total cholesterol
TG	Triglyceride
VO_2 max	Maximal oxygen uptake
WHO	World health organization

Availability of Data and Materials

The datasets generated and/or analysed during the current study are not publicly available due confidentiality but are available from the corresponding author on reasonable request.

Competing interests

AA, ZG and CWad and are employees of the Novartis Foundation (Basel, Switzerland). All other authors declare no financial competing interests.

Authors' contributions

All authors were involved in the design of the study and contributed to the development of the study protocol. UP and CW are the principal investigators. IM wrote the manuscript draft. All authors reviewed, edited and critically commented on the draft. All authors read and provided comments on the drafts and approved the final version of the paper prior to submission. UP and CW are guarantors of the paper.

Acknowledgements

The 'Disease, Activity and Schoolchildren's Health' (DASH) project was supported by the Swiss National Science Foundation (SNSF) and the National Research Foundation (NRF) South Africa as part of the Swiss-South African Joint Research Programme (SSAJRP). The Novartis Foundation, Nelson Mandela University, University of Basel and the Swiss Tropical and Public Health Institute have expanded the DASH programme into the 'Healthy Schools for Healthy Communities' initiative, which is called '*KaziBantu*' in Port Elizabeth, South Africa. We are thankful to the children and parents or guardians for their willingness to participate in the pilot testing of *KaziKidz*. Special thanks are also addressed to the education authorities of the schools, including the indispensable support for *KaziHealth* and collaboration of the teaching staff, community volunteers, and the respective school health services. Furthermore, we are thankful to the Master-students Roman Aebischer, Chantal Brügger, Melanie Glover, Nicola Hausner and Lize van der Walt who designed the *KaziKidz* teacher material and conducted the pilot testing. The *KaziBantu* project is registered under the International Standard Randomised Controlled Trial Number registry (ISRCTN18485542) and is funded by the Novartis Foundation. The funders played no role in the study design, data collection and analysis and decision to publish.

References

1. Dahlgren G, Whitehead M. Policies and strategies to promote social equity in health. Background document to WHO - Strategy paper for Europe. Stockholm: Institute for Future Studies; 1991. Arbeitsrapport. 14.

2. Marshall SJ. Developing countries face double burden of disease. Bull World Health Organ. 2004;82(7):556.

3. Boutayeb A. The double burden of communicable and non-communicable diseases in developing countries. Trans R Soc Trop Med Hyg. 2006;100(3):191-9.

4. Yap P, Müller I, Walter C, Seelig H, Gerber M, Steinmann P, et al. Disease, Activity and Schoolchildren's Health (DASH) in Port Elizabeth, South Africa: a study protocol. BMC public health. 2015;15(1):1285.

5. Murray CJL, Vos T, Lozano R, Naghavi M, Flagman AD, Michaud C, et al. Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990-2010: A systematic analysis for the Global Burden of Disease Study 2010. Lancet. 2012;380:2197-223.

6. Colley DG, Bustinduy AL, Secor WE, King CH. Human schistosomiasis. Lancet. 2014;383:2253-64.

7. Yap P, Wu FW, Du ZW, Hattendorf J, Chen R, Jiang JY, et al. Effect of deworming on physical fitness of school-aged children in Yunnan, China: A double-blind, randomized, placebo-controlled trial. PLoS Neglected Tropical Diseases. 2014;8(e2983):doi:10.1371/journal.pntd.0002983.

8. Utzinger J, Becker SL, Knopp S, Blum J, Neumayr AL, Keiser J, et al. Neglected tropical diseases: Diagnosis, clinical management, treatment and control. Swiss Medical Weekly. 2012;142:w13727.

827 9. Yap P, Du ZW, Chen R, Zhang LP, Wu FW, Wang J, et al. Soil-transmitted helminth
828 infections and physical fitness in school-aged Bulang children in southwest China: Results
829 form a cross-sectional survey. Parasites & vectors. 2012;5(50):10.1186/756-3305-5-50.
830 10. Hürlimann E, Houngbedji CA, N'Dri PB, Bänninger D, Coulibaly JT, Yap P, et al.
831 Effect of deworming on school-aged children's physical fitness, cognition and clinical
832 parameters in a malaria-helminth co-endemic area of Côte d'Ivoire. BMC Infectious Diseases.
833 2014;14(411):doi:10.1186/471-2334-14-411.
834 11. Faber M, Laurie S, Maduna M, Magudulela T, Muehlhoff E. Is the school food
835 environment conducive to healthy eating in poorly resourced South African schools? Public
836 Health Nutrition. 2013;17(6):1214-23.
837 12. Katzmarzyk P, Broyles S, Champagne C, Chaput J-P, Fogelholm M, Hu G.
838 Relationship between soft drink consumption and obesity in 9–11 years old children in a
839 multi-national study. Nutrients. 2016;8(12):770.
840 13. Draper CE, Tomaz SA, Bassett SH, Burnett C, Christie CJ, Cozett C, et al. Results
841 from South Africa's 2018 Report Card on Physical Activity for Children and Youth. J Phys
842 Act and Health. 2018;15(S2):S406-8.
843 14. Marshall SJ. Developing countries face double burden of disease. Bulletin of the
844 World Health Organization. 2004;82:556.
845 15. Hofman K. Non-communicable diseases in South Africa: a challenge to economic
846 development. South African medical journal = Suid-Afrikaanse tydskrif vir geneeskunde.
847 2014;104(10):647.
848 16. Steyn K, Damasceno A. Lifestyle and related risk factors for chronic diseases. In:
849 Jamison DT, Feachem RG, Makgoba MW, Bos ER, Baingana FK, Hofman KJ, et al., editors.
850 Disease and mortality in sub-Saharan Africa. 2nd ed. Washington (DC).2006.

17. Vorster H, Kruger A, Margetts B. The Nutrition Transition in Africa: Can It Be Steered into a More Positive Direction? Nutrients. 2011;3(4):429-41.

18. The NCD Alliance. A focus on Children and Non-Communicable Diseases (NCDs). Available from: https://ncdalliance.org/sites/default/files/rfiles/20110627_A_Focus_on_Children_&_NCDs_FINAL_2.pdf; Accessed on 14 January 2019.

19. Herman KM, Craig CL, Gauvin L, Katzmarzyk PT. Tracking of obesity and physical activity from childhood to adulthood: the Physical Activity Longitudinal Study. Int J Pediatr Obes. 2009;4(4):281-8.

20. Santosa A, Wall S, Fottrell E, Hogberg U, Byass P. The development and experience of epidemiological transition theory over four decades: a systematic review. Global health action. 2014;7:23574.

21. WHO. Preventing chronic diseases: a vital investment. Chronic diseases and health promotion 2015. Available from: http://www.who.int/chp/chronic_disease_report/part1/en/index11.html; Accessed on 6 September 2018.

22. Yap P, Müller I, Walter C, Seelig H, Gerber M, Steinmann P, et al. Disease, activity and schoolchildren's health (DASH) in Port Elizabeth, South Africa: A study protocol. BMC Public Health. 2015;15(1285):doi: 10.1186/s12889-015-2636-y.

23. Laurence EC, Volmink J, Esterhuizen TM, Dalal S, Holmes MD. Risk of cardiovascular disease among teachers in Cape Town: Findings of the South African PaCT pilot study. South African medical journal = Suid-Afrikaanse tydskrif vir geneeskunde. 2016;106(10):996–1001.

24. Senekal M, Seme Z, de Villiers A, Steyn NP. Health status of primary school educators in low socio-economic areas in South Africa. BMC public health. 2015;15:186.

876 25. Peltzer K, Shisana O, Zuma K, van Wyk B, Zungu-Dirwayi N. Job stress, job
877 satisfaction and stress-related illnesses among South African educators. Stress and Health.
878 2009;25:247-57.
879 26. Statistics South Africa. Statistical release mortality and causes of death in South
880 Africa, 2008: Findings from death notification. Stats SA. 2011.
881 27. International Diabetic Federation. IDF Africa Members 2018. Available from:
882 https://www.idf.org/our-network/regions-members/africa/members/25-south-africa; Accessed
883 on 6 December 2018.
884 28. Rajput D, Van Deventer K. An epoch of controversy within physical education and
885 sport in post-apartheid South Africa: A Review. African Journal for Physical, Health
886 Education, Recreation and Dance. 2010;16(1):147-65.
887 29. van Greunen D, Veldsman A, Haskins B, Ndame L, Botha J. *KaziHealth* Mobile
888 Application. INQB8 BT ed. Google Play. 2018.
889 30. Temple N, Steyn N. The KIDSCREEN questionnaires: Quality of life questionnaires
890 for children and adolescents. Community Nutrition for Developing Countries, Pretoria; Unisa
891 Press; The Kidscreen Group, Europe. 2006.
892 31. National Treasury of South Africa. Intergovernmental Fiscal Reviews (IGFR):
893 Education. Available from: www.treasury.gov.za; Accessed on 11 January 2019.
894 32. CDC. National Health and Nutrition Examination Survey (NHANES). Anthropometry
895 Procedures Manual. 2011. Available from:
896 https://www.cdc.gov/nchs/data/nhanes/nhanes_11_12/Anthropometry_Procedures_Manual.pd
897 f; Accessed on 15 November 2018.
898 33. Ravens-Sieberer U, Gosch A, Rajmil L, Erhart M, Bruil J, Duer W, et al.
899 KIDSCREEN-52 quality-of-life measure for children and adolescents. Expert review of
900 pharmacoeconomics & outcomes research. 2005;5(3):353-64.

34. Hong SD, Yang JW, Jang WS, Byun H, Lee MS, Kim HS, et al. The KIDSCREEN-52 quality of life measure for children and adolescents (KIDSCREEN-52-HRQOL): reliability and validity of the Korean version. Journal of Korean medical science. 2007;22(3):446-52.

35. Ravens-Sieberer U, Gosch A, Rajmil L, Erhart M, Bruil J, Power M, et al. The KIDSCREEN-52 quality of life measure for children and adolescents: psychometric results from a cross-cultural survey in 13 European countries. Value in health : the journal of the International Society for Pharmacoeconomics and Outcomes Research. 2008;11(4):645-58.

36. WHO. Health Behaviour In School-Aged Children. 2014. Available from: http://www.hbsc.org/about/index.html; Accessed on 27 December 2018.

37. Haugland S, Wold B, Torsheim T. Relieving the pressure? The role of physical activity in the relationship between school-related stress and adolescent health complaints. Research Quarterly for Exercise and Sport. 2003;74:127-35.

38. Richardson D, Cavill N, Ells L, Roberts K. Measuring Diet and Physical Activity in Weight Management Interventions: A Briefing Paper. Oxford Journals: National Obesity Observatory. 2011.

39. Europe Co. Testing physical fitness: Eurofit experimental battery. Strasbourg: Council of Europe. 1983.

40. Léger LA, Mercier D, Gadoury C, Lambert J. The multistage 20 meter shuttle run test for aerobic fitness. Journal of sports sciences. 1988;6(2):93-101.

41. John D, Freedson P. ActiGraph and Actical physical activity monitors: a peek under the hood. Medicine and science in sports and exercise. 2012;44(1 Suppl 1):S86-9.

42. Riebe D, Ehrman J, Liguori G, Magal M. ACSM's Guidelines For Exercise Testing And Prescription. 10th ed. Sport & Exercise Scientist. Wolters Kluwer. 2017.

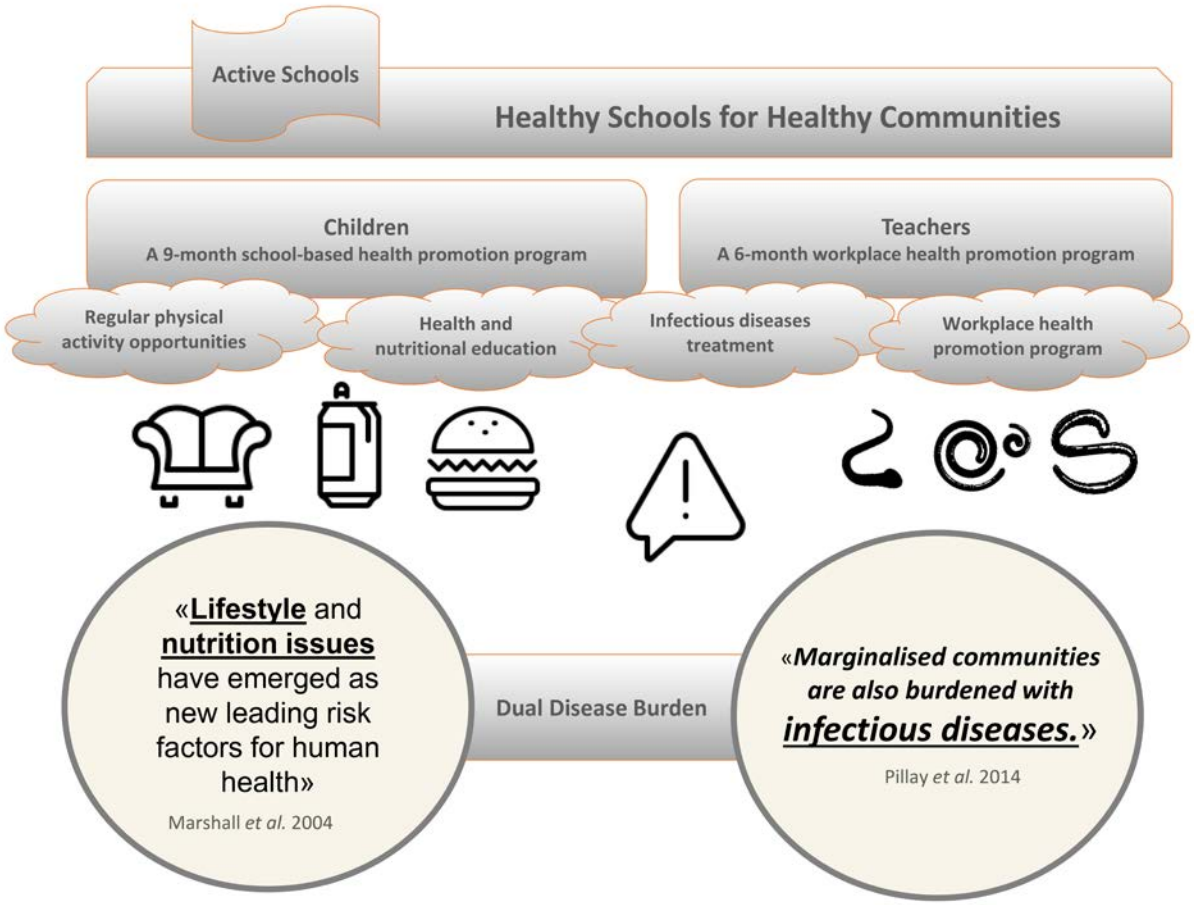
43. Cooper KH. A Means of Assessing Maximal Oxygen Intake: Correlation Between Field and Treadmill Testing. JAMA J Am Med Assoc. 1968;3(203):201–4.

926 44. Siegrist J, Starke D, Chandola T, Godin I, Marmot M, Niedhammer I. The
927 measurement of effort-reward imbalance at work: European comparisons. Soc Sci Med.
928 2004;8(58):1483–99.
929 45. Lundgren-Nilsson A, Jonsdottir IH, Pallant J, Ahlborg G, Jr. Internal construct validity
930 of the Shirom-Melamed Burnout Questionnaire (SMBQ). BMC public health. 2012;12:1.
931 46. Morin CM, Belleville G, Belanger L, Ivers H. The Insomnia Severity Index:
932 psychometric indicators to detect insomnia cases and evaluate treatment response. Sleep.
933 2011;34(5):601-8.
934 47. Müller I, Beyleveld L, Gerber M, Pühse U, Du Randt R, Utzinger J, et al. Low
935 efficacy of albendazole against Trichuris trichiura infection in schoolchildren from Port
936 Elizabeth, South Africa. Transactions of the Royal Society of Tropical Medicine and
937 Hygiene. 2016;00(1-3):doi:10.1093/trstmh/trw075.
938 48. Gall S, Müller I, Walter C, Seelig H, Steenkamp L, Pühse U, et al. Associations
939 between selective attention and soil-transmitted helminth infections, socioeconomic status and
940 physical fitness in disadvantaged children in Port Elizabeth, South Africa: An observational
941 study. PLoS Neglected Tropical Diseases. 2017;8:doi: 10.1371/journal.pntd.0005573.
942 49. Salvini M, Gall S, Müller I, Walter C, Du Randt R, Steinmann P, et al. Physical
943 activity and health-related quality of life among schoolchildren from disadvantaged
944 neighbourhoods in Port Elizabeth, South Africa. Quality of Life Research. 2017:doi:
945 10.1007/s11136-017-1707-1.
946 50. Gerber M, Müller I, Walter C, Du Randt R, Adams L, Gall S, et al. Physical activity
947 and dual disease burden among South African primary schoolchildren from disadvantaged
948 neighbourhoods. Prev Med. 2018;112:104-10.
949 51. Gall S, Adams L, Joubert N, Ludyga S, Müller I, Nqweniso S, et al. Effect of a 20-
950 week physical activity intervention on selective attention and academic performance in

951 children living in disadvantaged neighborhoods: A cluster randomized control trial. PloS one.
952 2018;13(11):e0206908.
953 52. Müller I, Schindler C, Adams L, Endes K, Gall S, Gerber M, et al. Effect of a
954 multidimensional physical activity intervention on body mass index, skinfolds and fitness in
955 South African children: results from a cluster-randomised controlled trial. Int J Environ Res
956 Publ Health. 2019;16(2):232.
957 53. Deaton A, Tortora R. People In Sub-Saharan Africa Rate Their Health And Health
958 Care Among The Lowest In The World. Health Affairs. 2015;34(3):519-27.
959 54. Deaton A. Height, health, and development. Proc Natl Acad Sci USA.
960 2007;104(33):13232-7.
961

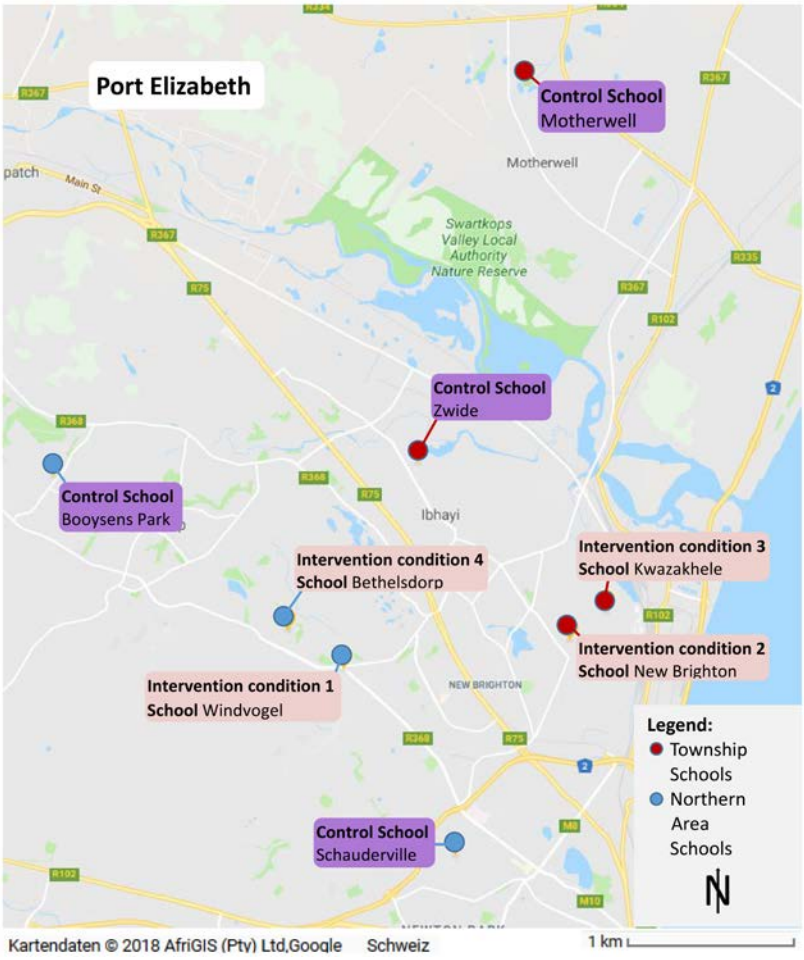
Figures

Figure 1 A conceptual framework of the *KaziBantu* study



962

Figure 2 Study area, Port Elizabeth, South Africa, and location of the 8 schools participating in the *KaziBantu* study



963

Figure 3 **A pictorial display of the *KaziBantu* study design**

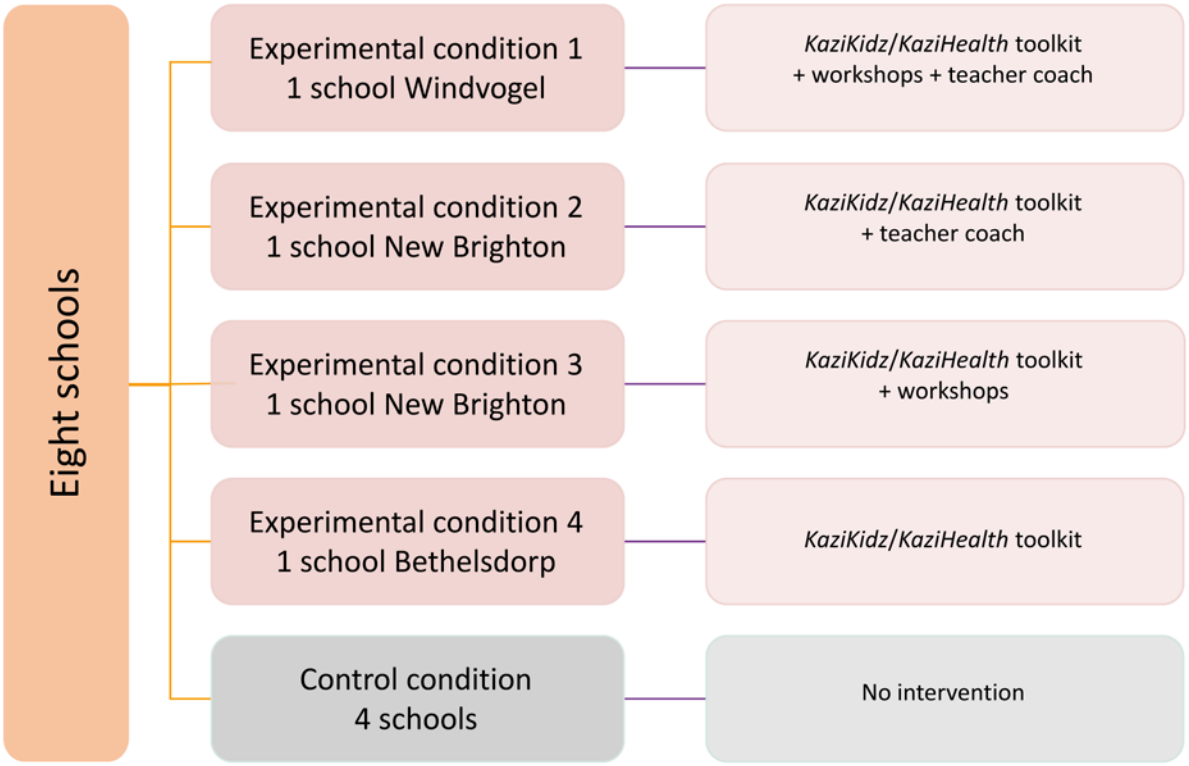


Figure 4 ***KaziBantu*** **study design of testing the** ***KaziKidz*** **teaching material**

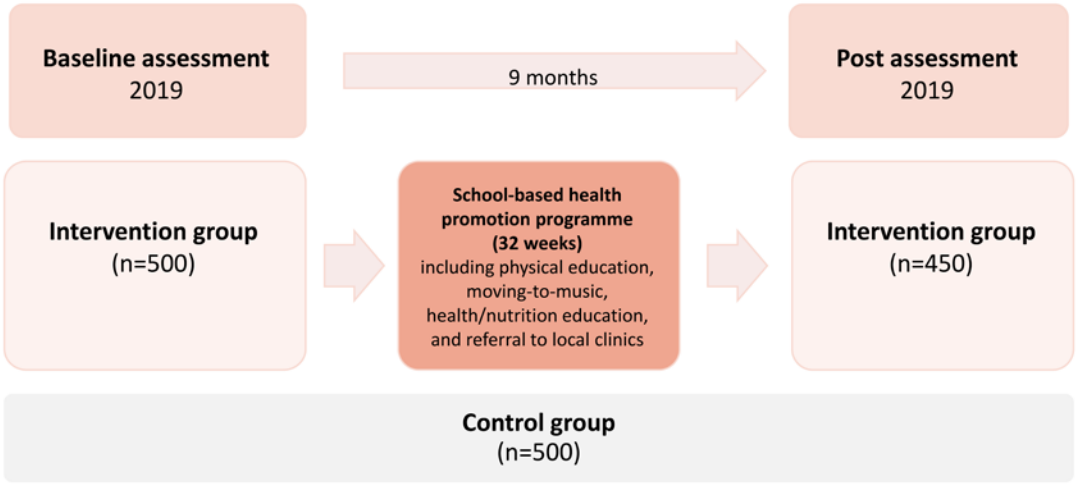


Figure 5 ***KaziBantu*** **study design of testing the** ***KaziHealth*** **tools**

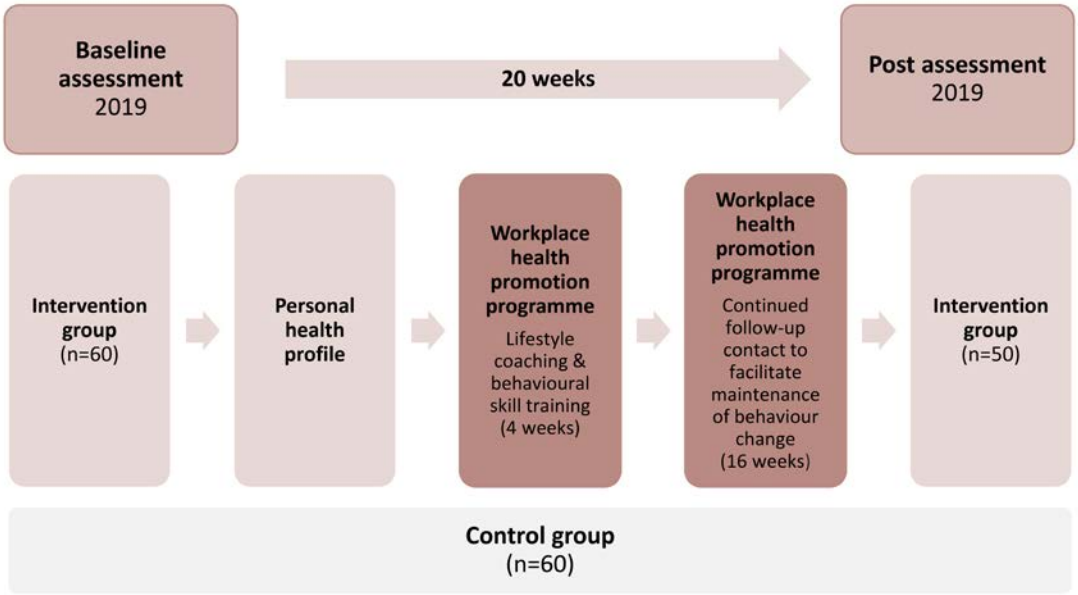
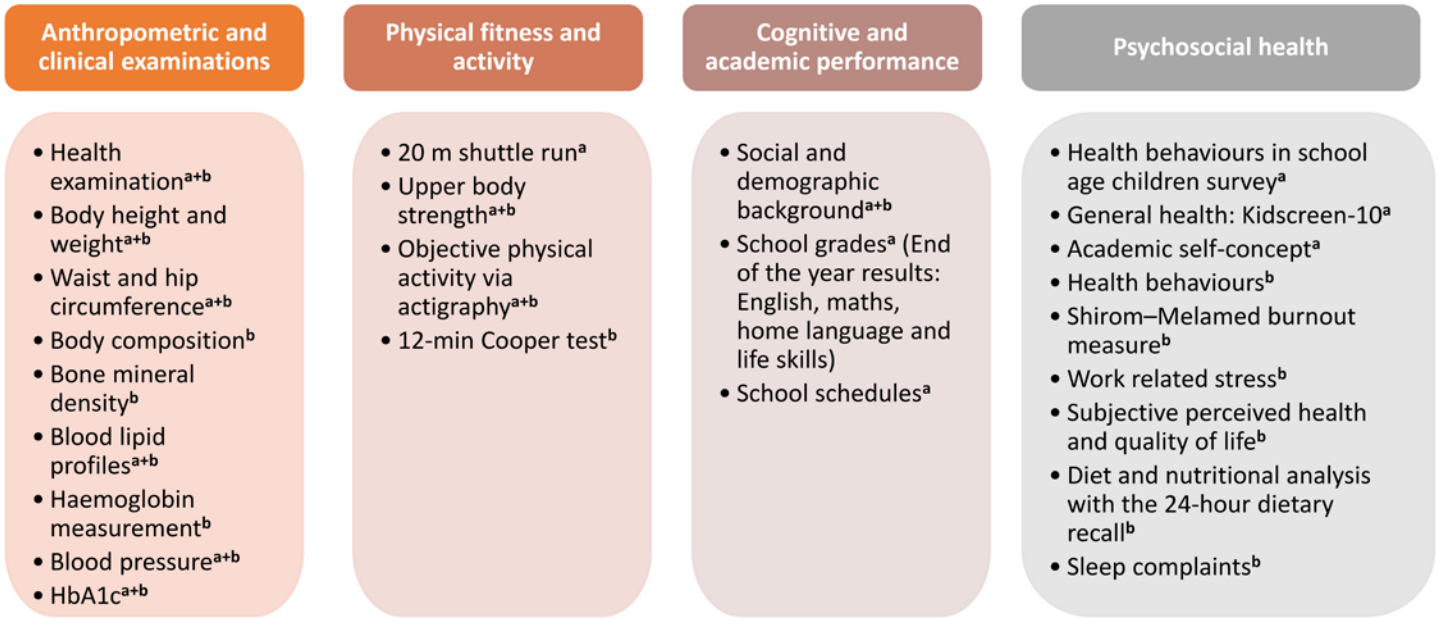


Figure 6 **20-week workplace health promotion programme for teachers**

970
971

Figure 7 **Measurements and tests performed among schoolchildren[a] and teachers[b] in the *KaziBantu* study**



[a] Children's measurement
[b] Teachers' measurement