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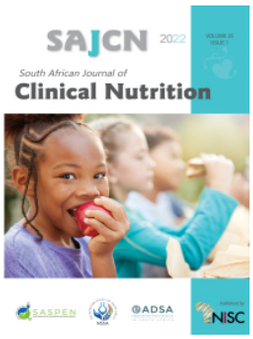
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ARTICLE

Associations between nutrition knowledge and obesity-related attitudes and physical activity among young adults from Kenya, South Africa, and the United Kingdom

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Objective: This study's aim was to test associations between nutrition knowledge and obesity-related attitudes and physical activity (PA) among 3000 18–35-year-old men and women from Kenya, South Africa (SA), and the United Kingdom (UK).
Methods: A cross-sectional online survey was conducted in April 2022. To estimate nutrition knowledge, dietary recommendation knowledge score was computed using the standard General Nutrition Knowledge questionnaire. Obesity-related attitudes were from the British Social Attitudes Survey. Self-reported days of vigorous and moderate PAs and walking were used. Ordinal logistic regression was employed to test all associations, while adjusting for age group, gender and a household asset score. Using simple mediation, testing was also done to ascertain whether obesity-related attitudes mediated associations between nutrition knowledge and PA.
Results: Consistently, better nutrition knowledge was associated with disagreeing that 'There is no reason to worry about obesity' (ORs $\geq$ 1.09), but lower odds of being against 'Providing free weight management courses' and 'Creating/improving cycle paths and pavements to encourage PA' (ORs $\leq$ 0.90). Better nutrition knowledge was also associated with higher vigorous PA in SA (OR = 1.09), and moderate PA (OR = 1.04) and walking (OR = 1.12) in the UK. In the combined sample, associations of nutrition knowledge with vigorous PA were fully mediated by believing that 'Obesity results from not exercising enough' (11.1% mediated). Likewise, associations of nutrition knowledge with moderate PA were fully mediated by attitude towards 'Creating or improving cycle paths and pavements to encourage PA' in the UK (38.9% mediated).
Conclusions: Nutrition knowledge is associated with obesity-related attitudes and PA among young adults, but some relationships are country-specific. Interventions based on findings from high-income countries should be evaluated before being implemented in low-resource settings.

Keywords nutrition knowledge, obesity attitudes, physical activity, multi-country, young adults, South Africa, Kenya, United Kingdom

Introduction

Although obesity-related non-communicable diseases (NCDs) remain the leading cause of death, their impact can be effectively controlled by reducing certain behavioural risk factors, such as unhealthy eating and physical inactivity.[1] There has been a rapid rise in these risk factors, due to globalisation of unhealthy lifestyles and poorly planned urbanisation.[2] Accordingly, high-income countries (HICs) including the United Kingdom (UK) are being highly affected, and low- and middle-income countries (LMICs) like Kenya and South Africa (SA) have the highest future projections of NCD prevalence.[3]

The effectiveness of interventions aimed at reducing obesity may be challenged by public-health-related issues including low health literacy and inaccurate health knowledge.[4] What is also crucial in this context is obesity-related attitudes, including beliefs regarding obesity causes and attitudes towards its policies, as these impact on both individual health behaviour and willingness to support collective actions.[5] Compared with those who thought differently, people who believed that obesity is mainly caused by factors outside individual control (food environments and genetics) reported lower physical activity (PA) levels.[6] However, individuals with those beliefs also showed greater support towards policies that tackle obesity compared with those who thought obesity is caused by factors that are within the individual's control (diet and physical inactivity).[5]

Understanding factors that influence obesity-related attitudes, and also their impact on PA, may be key to developing effective interventions to tackle obesity. This is because factors that lead to negative attitudes towards obesity may also impact on the motivation to engage in PA and maintain healthy bodyweight statuses. Different factors are known to influence obesity-related attitudes, including age, gender and socioeconomic status, but education was the strongest predictor.[5,7,8] Findings from the 2015 British Social Attitudes survey demonstrated that individuals with no educational qualifications were more likely than graduates to agree that being overweight is caused by low metabolism.[8] The same survey demonstrated that individuals with a higher level of education were likely to favour policies that discourage unhealthy eating.[8] It is possible

that the higher the level of education, the more likely an individual is to know about health-related issues, and that this influences their attitudes towards health-related policies, and even their health behaviour like PA. In an online survey experiment, a health education intervention, through media and public health campaign, resulted in changes in obesity-related attitudes in adults, but the influence on PA was not assessed.[9]

The link between health education and obesity-related attitudes may be partly driven by general nutrition knowledge (GNK) – a key component of health knowledge. Like obesity-related attitudes, GNK has been shown to differ by age, gender and socioeconomic status.[10] However, previous studies that investigated associations between GNK and health-related attitudes focused on attitudes towards nutrition and dietary intake, using Knowledge–Attitude–Practice (KAP) survey methods.[11,12] In those studies, GNK was more strongly associated with nutrition-related attitudes compared with dietary intake.[12–14] Those findings supported the notion that the associations between knowledge and practices are mediated by attitudes. It is therefore possible that GNK also influenced obesity-related attitudes and PA behaviours, but this warrants further investigation.

Here, we tested relationships between GNK, obesity-related attitudes and PA among young adults from Kenya, SA and the UK. We hypothesised that better GNK was associated with higher PA and that this relationship was mediated by obesity-related attitudes.

Methodology

Study design, setting and survey integrity

This cross-sectional study included 3 000 participants from Kenya, SA, and the UK ($n = 1$ 000 and 50% females per country). Using the IPSOS i-Say panel, we recruited participants within the age range 18–35 years and conducted the survey online in April 2022. Overall, the sample was targeted to be nationally representative of each country's 18-to-35-year-olds who had internet access. Steps used to ensure survey integrity are summarised in Supplementary Figure S1. Details regarding steps used in participant recruitment have been described elsewhere[15]. All participants provided written informed consent before being included in the study.

Our survey included questions on the respondent's gender (male or female), household assets, GNK, obesity-related attitudes (beliefs concerning obesity and attitudes towards obesity policies) and PA behaviour.

We used a household asset score as a proxy for socioeconomic status. To calculate the household asset score, we gave each respondent a score of one for having each of the following 22 assets: Furniture (Sofa or armchairs); Mattress; Bed; Gas (or kerosene) cooker; Stove (electric or gas); Refrigerator; Air conditioner; Washing machine; Bicycle; Motorbike; Cars and other 4-wheel vehicles; Generator; Fan; Microwave; Television; Computer or tablet; Satellite dish; Smartphone; Mobile feature phone (excluding smartphones); Flush toilet in-/outside house; Tap water in house/on plot; and Electricity.

We estimated GNK using an instrument from the standard GNK questionnaire.[16] Briefly, the GNK questionnaire comprises four sections that have been independently validated in different populations and each testing different aspects of GNK. In this study, we included only the nine questions from the dietary recommendation section. We then calculated a dietary recommendation knowledge score (DRKS) by giving each correct response a score of one, allowing for a maximum total score of 18. A higher DRKS indicated better nutrition knowledge. Questions relating to beliefs concerning obesity and attitudes towards obesity policies were as presented in the British Social Attitudes Survey.[8] For each question or statement, we presented the response options as a five-point Likert scale, ranging from strongly agree/in favour to strongly disagree/against.

To estimate PA behaviour, the survey respondents were asked to indicate the number of days they had spent doing (1) vigorous PA (like heavy lifting, digging, aerobics or fast bicycling); (2) moderate PA (like carrying light loads, bicycling at a regular pace or doubles tennis); during the previous seven days. The World Health Organization recommends that 18–64-year-olds do muscle-strengthening activities at moderate or greater intensity that involve all major muscle groups on two or more days a week.[17] Accordingly, we categorised both vigorous and moderate PA days into three groups (i) 0 to 1 day; (ii) 2 to 3 days; and (iii) 4 to 7 days per week. To estimate walking, the participants were asked on how many days they walked for at least 10 minutes at a time, during the previous 7 days. To obtain similar proportions in each group, we categorised walking into the following three categories: (i) 0 to 3 days per week; (ii) 4 to 6 days per week; and (iii) every day.

Ethics

As a polling company, IPSOS and its associates do not have to obtain ethical approval for recruiting their participants. The polling companies must only comply with the industry standards and regulations set out by market institutions such as the South African Market Research Association, the European Society for Opinion and Market Research (ESOMAR), and the Protection of Personal Information Act in South Africa. Within this context, Kenya adheres to ESOMAR, while the UK adheres to the Market Research Society and General Data Protection Regulation regulations. Nevertheless, we conducted this study in accordance with the guidelines laid down in the Declaration of Helsinki. All procedures involving the research study participants were approved by the University of the Witwatersrand Human Research Ethics Committee, Non-medical (Clearance number H21/05/49). We obtained written informed consent from all study participants.

Data analysis

We conducted all statistical analyses in R version 4.2.1 (R Foundation for Statistical Computing, Vienna, Austria). To compare the continuous variables statistically, we used a Wilcoxon signed-rank test for gender (men vs. women) and a Kruskal–Wallis test for countries (Kenya vs. SA vs. UK). We used a chi-square test to compare statistically the categorical variables for both gender and countries.

Our main hypothesis was that GNK influences PA behaviour, and that this relationship is mediated via obesity-related attitudes (Figure S2). However, the relationships between GNK and obesity-related attitudes and PA are not well established. Therefore, as first steps, we used ordinal logistic regression models to evaluate associations between DRKS (predictor) and obesity-related attitudes (outcome) (Path α in Figure S2), Obesity-related attitudes (predictor) and PA (outcome) (Path β in Figure S2), and DRKS (predictor) and PA (outcome) (Path c' in Figure S2).

In all statistical models, we adjusted for age group, gender and household asset score. We first stratified the participants by country and then combined the samples to get the combined estimates while including country as an additional confounder. We used Bonferroni correction to adjust for multiple testing in all regression models that involved obesity-related attitudes ($p = 0.050/14$ attitudes $= 0.004$). Accordingly, we considered $p < 0.004$ to indicate sufficient evidence of association in all models that involved obesity-related attitudes.

Only attitudes that were significantly associated with both DRKS and PA ($p < 0.004$), in at least one stratum (Kenya, SA, UK and/or combined) were included in the mediation analysis. The 'lavaan' R package was used to conduct simple mediation analyses of the effects of DRKS (predictor) on PA (outcome), with obesity-related attitudes as mediators. The total, direct and indirect effects were reported in the mediation results. The percentage of mediation effect (% mediated) was calculated using the following equation: (Indirect effect/Total effect) x 100.

Results

Basic characteristics

Basic characteristics of the study sample are given in Table S1. Data used in the present study had no missingness. When comparing countries, the proportion of participants in each age group, average household asset score, average DRKS, and reported PA differed among the three countries (all $p < 0.001$, not shown in Table S1).

When comparing gender, there were no differences in the household asset score in any of the three countries. However, only in the UK, the proportion of respondents in each age group differed between men and women ($p < 0.001$). In SA and the UK, the DRKS was higher in women compared with men ($p < 0.001$ in both countries). Compared with women, men reported more days of both moderate and vigorous PA in all three countries and in the combined sample (all $p < 0.001$). However, more days of walking in men compared with women were reported only in Kenya ($p = 0.013$) and SA ($p = 0.008$) and in the combined sample ($p = 0.002$) but not in the UK.

Beliefs concerning obesity among young adults

Beliefs concerning obesity are compared by country and gender in Figure S3. All beliefs regarding obesity differed among the three countries (all $p < 0.001$, not shown). While there was evidence of gender difference in the proportion of responses to all included belief statements in the UK, only the belief that 'Most people who are overweight have put on weight because they exercise too little' differed by gender in Kenya. In SA, only responses to the beliefs that 'There is no reason to worry about being a bit overweight', 'Most people who are overweight have put on weight because they eat too much', and 'Most people who are overweight have put on weight because they exercise too little' differed by gender.

Overall, in the combined sample that included both genders, there were more (54.6%) respondents who disagreed that 'There is no reason to worry being a bit overweight' than those who agreed (28.2%). Likewise, a larger proportion of respondents disagreed (50.7%) that 'Being overweight is something you inherit from your parents' compared with those who agreed (21.5%). Conversely, more respondents agreed (43.6%) that 'Most people have put on weight because of low metabolism' than those who disagreed (21.4%). Similarly, there were more respondents who agreed that 'Most people who are overweight have put on weight because they eat too much' (52.8%) or 'they exercise too little' (60.0%) compared with those who disagreed (24.0% and 17.2%, respectively).

Attitudes towards obesity policies among young adults

Attitudes towards obesity policies are compared by country and gender in Figures S4–S7. Similar to beliefs concerning obesity, there was evidence of country differences in all attitudes towards obesity policies (all $p < 0.001$, not shown). The responses that differed by gender were 'Providing many more free weight management courses for people who want to lose weight' in Kenya only (Figure S4), 'Providing many more operations on the governments' department of health to help people lose weight' in SA only (Figure S5), and 'Raising taxes on fuel and parking to encourage people to walk and cycle more' in the UK only (Figure S6).

Overall, in the combined sample that included both genders (Figure S7), the majority of participants were in favour of most of the obesity policies, including 'Putting a tax on high fat foods, which would increase the price of things like crisps and chocolate' (44.0% in favour vs. 32.8% against); 'Putting a tax on sugary fizzy drinks' (43% in favour vs 29.0% against); 'Banning adverts for high fat foods, like crisps and chocolate' (39.2% in favour vs. 32.7% against); 'Banning adverts for sugary fizzy drinks' (39.4% in favour vs. 31.3% against); 'Reducing the standard size of unhealthy snacks or drinks' (55.2% in favour vs. 21.9% against); 'Providing many more free weight management courses for people who want to lose weight' (82.7% in favour vs. 16.3% against); 'Providing many more operations on the governments' department of health to help people lose weight' (62.7% in favour vs. 12.3% against); and 'Doing more to create or improve cycle paths and pavements to encourage people to be more active' (77.5% in favour vs. 4.5% against). Conversely, the majority of respondents were against 'Raising taxes on fuel and parking to encourage people to walk and cycle more' (26.5% in favour vs. 49.9% against).

Associations between nutrition knowledge and beliefs about obesity

Associations between the DRKS (predictor) and Likert responses to beliefs concerning obesity (outcomes) are summarised in Figure 1(a), with the corresponding p-values shown in Supplementary Table S2. $P < 0.004$ was considered as sufficient evidence of association. For all three countries, better nutrition knowledge was associated with greater odds of disagreeing that 'There is no reason to worry about being a bit overweight' (ORs ≥ 1.088). Associations in the same direction were also observed but only in the UK, and combined samples for the beliefs that 'Being overweight is something you inherit from your parents' and that 'Most overweight people have put on weight because of low metabolism' (ORs ≥ 1.051). Only in the combined sample was better nutrition knowledge associated with lower odds of disagreeing with the belief that 'Most people who are overweight have put on weight because they exercise too little' (OR = 0.960).

Associations between nutrition knowledge and attitudes towards obesity policies

Association between the DRKS (predictor) and Likert responses to attitudes towards obesity policies (outcomes) are summarised in Figure 1(b), with the p-values shown in Supplementary

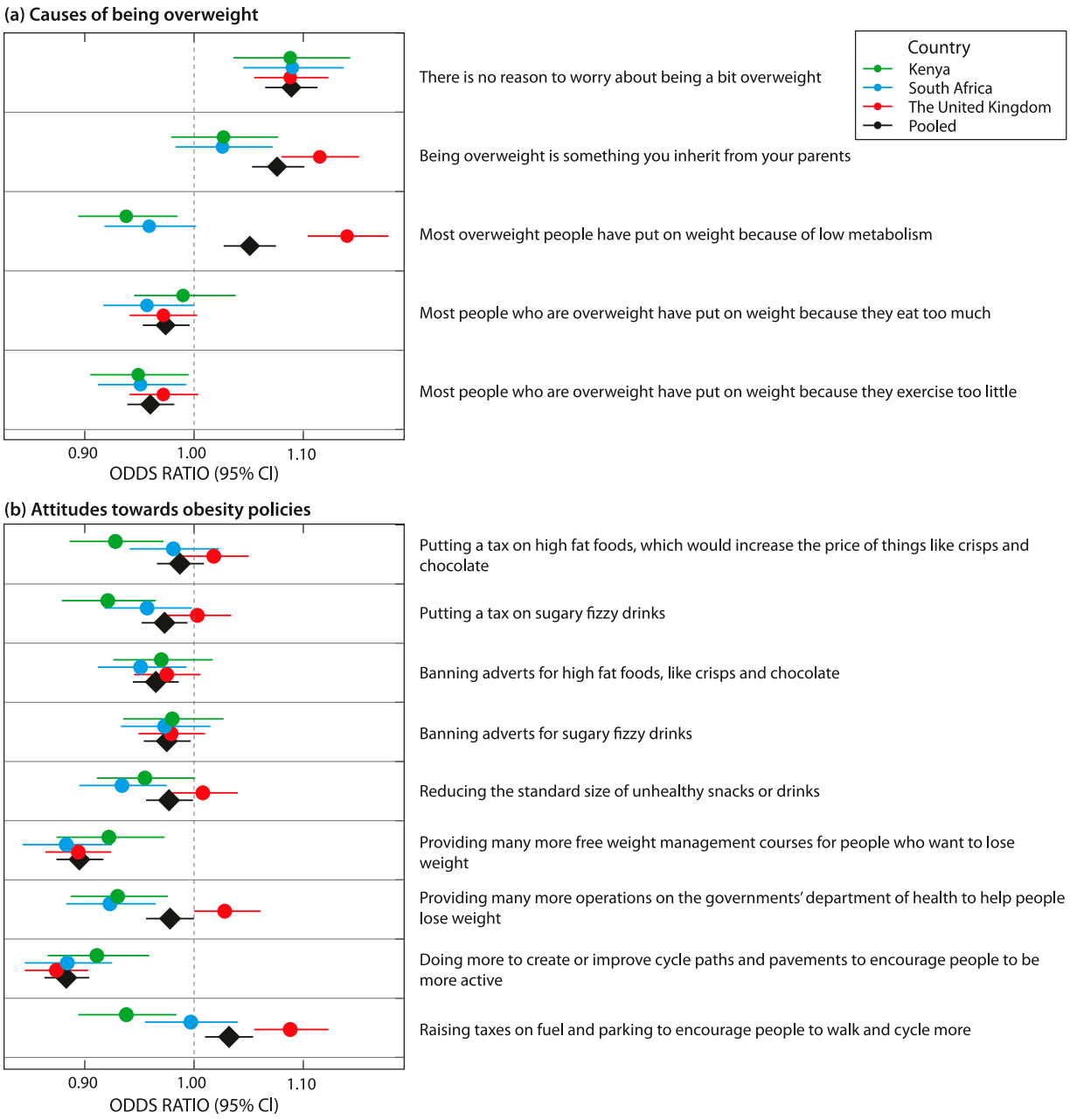


Figure 1: Associations between the dietary recommendation score and (a) beliefs concerning obesity and (b) attitudes towards obesity policies. 95% CI: 95% confidence interval. Ordered logistic regression models were used. The dietary recommendation score was included as the predictor, while Likert responses to questions related to beliefs concerning being overweight were the outcomes (factor levels: 1 = strongly agree/in favour, 2 = agree/in favour, 3 = neutral, 4 = disagree/against, 5 = strongly disagree/against). All presented regression models were adjusted for age group, gender and household asset score. Country was included as an additional confounder in the combined sample. The corresponding *p*-values for each model are presented in Supplementary Tables S2 and S3, respectively.

Table S3. $P < 0.004$ was considered as sufficient evidence of association.

In all three countries and in the combined sample, better nutrition knowledge was associated with lower odds of being against 'Providing many more free weight management courses for people who want to lose weight' and 'Doing more to create or improve cycle paths and pavements to encourage people to be more active' (ORs ≤ 0.895). Only in the combined sample was better nutrition knowledge associated with lower odds of being against 'Banning adverts for high fat foods' (OR = 0.965). Only in Kenya was better nutrition knowledge associated with lower odds of being against putting taxes on unhealthy food products like 'high fat foods' and 'fizzy drinks' (ORs ≤ 0.921). Only in SA was better nutrition knowledge associated with lower odds of being against 'Reducing the standard size of unhealthy snacks or drinks' (OR = 0.934). Only in the UK was better nutrition knowledge associated with higher odds of being against 'Raising taxes on fuel and parking to encourage people to walk and cycle more' (OR = 1.088). While better nutrition knowledge was associated with lower odds of being against 'Providing many more operations on the governments' department of health to help people lose weight' in Kenya and SA (ORs ≤ 0.923), there was no evidence of this association in the UK.

Associations between beliefs concerning obesity and physical activity

The associations between beliefs concerning obesity (predictor) and PA (outcome) are given in Table 1. Only models where at

least one sample stratum showed sufficient evidence of association ($p < 0.004$) are presented in Table 1. All tested models are listed in Supplementary Table S4.

None of the included beliefs concerning obesity was associated with PA in Kenya. In SA, those who indicated a neutral response to the belief that 'Being overweight is something you inherit from your parents' were less likely to be in a higher category of vigorous PA compared with those who strongly agreed (OR = 0.407). In the UK, those who were neutral to the statement that 'There is no reason to worry about being a bit overweight' were less likely to be in a higher category of moderate PA compared with those who strongly agreed (OR = 0.532). Again, in the UK, those who responded with 'Agree' and 'Disagree' to the belief that 'Most people who are overweight have put on weight because they eat too much', were both less likely to be in a higher category of vigorous PA compared with those who strongly agreed (ORs ≤ 0.622).

When the three countries were combined, participants who agreed and also those who were neutral to the belief that 'There is no reason to worry about being a bit overweight' were both less likely to be in a higher category of vigorous PA compared with those who strongly agreed (ORs ≤ 0.666). In that same sample, those who responded with neutrality to that same belief were also less likely to be in a higher level of moderate PA compared with the reference group (OR = 0.644). Again, in the combined sample, for the belief that 'Being overweight is something you inherit from your parents', those who responded with either 'Neutral' or 'Disagree' were less likely to be in a higher level of vigorous PA compared with those who strongly agreed (ORs ≤ 0.617). In the same sample and in response to the belief that 'Most overweight people have put on weight because of low metabolism', those who were neutral were also less likely to be in a higher level of vigorous PA compared to those who strongly agreed (OR = 0.650). Furthermore, in the combined sample, those who responded with 'Disagree' to the belief that 'Most people who are overweight have put on weight because they eat too much' were less likely to be at a higher level of vigorous PA (OR = 0.701). Finally, in that combined sample, participants who indicated either 'Agree', 'Neutral' or 'Disagree' to the belief that 'Most people who are overweight have put on weight because they exercise too little' were also less likely to be in a higher level of vigorous PA, compared with the reference group (ORs ≤ 0.752).

Associations between attitudes towards obesity and physical activity

The associations between attitudes towards obesity policies (predictor) and PA (outcome) are given in Table 2. Only models where at least one sample stratum showed sufficient evidence of association ($p < 0.004$) are presented in Table 2. All tested models are listed in Supplementary Table S5.

Similar to beliefs concerning obesity, none of the included attitudes towards obesity statements was associated with PA in Kenya. In SA, participants who were neutral to 'Reducing the standard size of unhealthy snacks or drinks' were less likely to be in a higher category level of vigorous PA, compared with those who were strongly in favour (OR = 0.592). In the same sample, participants who were strongly against 'Raising taxes on fuel and parking to encourage people to walk and cycle more' were also less likely to be at a higher level of moderate PA (OR = 0.563).

In the UK, participants who were against 'Putting a tax on high fat foods, which would increase the price of things like crisps and chocolate' were less likely to be at a higher level of vigorous PA, compared with those who were strongly in favour (OR = 0.550). In that same sample, those who were neutral to 'Doing more to create or improve cycle paths and pavements to encourage people to be more active' were less likely to report higher levels of moderate PA, compared with the reference group (OR = 0.551). To that same statement and in the same sample, those who were either 'In Favour' or 'Neutral' were also less likely to be in a higher category of walking (ORs ≤ 0.627). Again, in the UK, those who were neutral to 'Raising taxes on fuel and parking to encourage people to walk and cycle more' were also less likely to be in a higher level of both vigorous and moderate PA, compared with those who were strongly in favour (ORs ≤ 0.532).

When all three countries were combined, those who were against 'Putting a tax on high fat foods, which would increase the price of things like crisps and chocolate' were less likely to be at a higher level of vigorous PA, compared with those who were strongly in favour (OR = 0.721). For that same statement and in the same sample, those who indicated 'Strongly Against' were less likely to be at a higher level of moderate PA (OR = 0.686). In the combined sample, being against 'Putting a tax on sugary fizzy drinks' was associated with lower odds of being at a higher level of vigorous PA, compared with being strongly in favour (OR = 0.731). However, those who were neutral to 'Reducing the standard size of unhealthy snacks or drinks' and to 'Providing many more free weight management courses for people who want to lose weight' were also less likely to be at a higher level of vigorous PA compared with the reference group in the combined sample (ORs ≤ 0.733). Also in the combined sample, those who were neutral to 'Doing more to create or improve cycle paths and pavements to encourage people to be more active' were less likely to be at a higher level of moderate PA compared with the reference group (OR = 0.683). For that same statement and same sample, those who were either 'In Favour', 'Neutral' or 'Against' were also less likely to be at a higher level of walking, compared with those who were strongly in favour (ORs ≤ 0.759). Again, in the combined sample, those who were either 'Neutral' to or 'Strongly Against' 'Raising taxes on fuel and parking to encourage people to walk and cycle more' were also less likely to be at a higher level of vigorous and also moderate PA compared with those who were strongly in favour (ORs ≤ 0.685). For that same statement and the same sample, those who indicate 'Against' were also less likely to be at a higher level of vigorous PA compared with those who were strongly in favour (OR = 0.679).

Associations between nutrition knowledge and physical activity

Table 3 shows associations between DRKS (predictor) and PA (outcome). There was no association between DRK and PA in Kenya. In contrast, better nutrition knowledge was associated with being at a higher level of vigorous PA in SA (OR = 1.086), and with being at a higher level of moderate PA (OR = 1.043) and walking (OR = 1.115) in the UK.

However, when all three countries were combined, better nutrition knowledge was associated with greater odds of being at a higher level of vigorous and moderate PA, and higher levels of walking (ORs = 1.026, 1.029 and 1.068, respectively).

Table 1: Associations between beliefs concerning obesity (predictors) and physical activity (outcomes).

Physical activity	Ref: Strongly agree	Kenya (*n* = 1 000)		South Africa (*n* = 1 000)		UK (*n* = 1 000)		Combined (*n* = 3 000)	
		OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*
There is no reason to worry about being a bit overweight									
Vigorous	Agree	0.670 (0.396 to 1.130)	0.134	0.710 (0.449 to 1.121)	0.142	0.610 (0.408 to 0.911)	0.016	0.666 (0.513 to 0.863)	**0.002**
	Neutral	0.530 (0.308 to 0.908)	0.021	0.720 (0.467 to 1.105)	0.134	0.562 (0.366 to 0.859)	0.008	0.614 (0.472 to 0.799)	< **0.001**
	Disagree	0.762 (0.478 to 1.209)	0.251	0.830 (0.561 to 1.226)	0.351	0.685 (0.461 to 1.016)	0.061	0.765 (0.604 to 0.967)	0.026
	Strongly disagree	0.889 (0.530 to 1.487)	0.653	0.881 (0.573 to 1.352)	0.561	0.685 (0.402 to 1.164)	0.163	0.830 (0.632 to 1.089)	0.179
Moderate	Agree	1.049 (0.619 to 1.775)	0.859	0.990 (0.626 to 1.566)	0.967	0.839 (0.564 to 1.246)	0.384	0.913 (0.705 to 1.182)	0.491
	Neutral	0.721 (0.422 to 1.230)	0.231	0.763 (0.496 to 1.174)	0.220	0.532 (0.348 to 0.812)	**<0.004**	0.644 (0.495 to 0.836)	**0.001**
	Disagree	0.819 (0.516 to 1.294)	0.393	0.876 (0.595 to 1.289)	0.503	0.837 (0.566 to 1.237)	0.372	0.808 (0.640 to 1.019)	0.073
	Strongly disagree	1.034 (0.616 to 1.731)	0.898	0.712 (0.466 to 1.087)	0.115	0.948 (0.564 to 1.592)	0.839	0.823 (0.628 to 1.077)	0.156
Being overweight is something you inherit from your parents									
Vigorous	Agree	1.332 (0.639 to 2.774)	0.443	0.510 (0.280 to 0.918)	0.026	0.586 (0.371 to 0.923)	0.022	0.651 (0.471 to 0.898)	0.009
	Neutral	1.249 (0.617 to 2.523)	0.535	0.407 (0.233 to 0.700)	**0.001**	0.639 (0.408 to 0.999)	0.050	0.617 (0.454 to 0.837)	**0.002**
	Disagree	1.233 (0.624 to 2.432)	0.545	0.443 (0.252 to 0.768)	0.004	0.560 (0.363 to 0.862)	0.009	0.608 (0.450 to 0.821)	**0.001**
	Strongly disagree	1.308 (0.643 to 2.657)	0.457	0.430 (0.237 to 0.771)	0.005	0.682 (0.404 to 1.148)	0.151	0.651 (0.468 to 0.903)	0.010
Most overweight people have put on weight because of low metabolism									
Vigorous	Agree	0.968 (0.657 to 1.423)	0.867	0.783 (0.531 to 1.151)	0.214	0.581 (0.369 to 0.910)	0.018	0.783 (0.621 to 0.987)	0.039
	Neutral	0.673 (0.454 to 0.995)	0.048	0.707 (0.483 to 1.034)	0.074	0.527 (0.339 to 0.816)	0.004	0.650 (0.516 to 0.818)	**<0.001**
	Disagree	0.832 (0.530 to 1.302)	0.420	1.089 (0.657 to 1.810)	0.740	0.601 (0.380 to 0.948)	0.029	0.804 (0.619 to 1.044)	0.102
	Strongly disagree	1.261 (0.625 to 2.565)	0.519	1.247 (0.588 to 2.678)	0.567	0.556 (0.300 to 1.024)	0.060	0.912 (0.621 to 1.341)	0.640
Most people who are overweight have put on weight because they eat too much									
vigorous	Agree	1.169 (0.783 to 1.745)	0.445	0.819 (0.596 to 1.123)	0.215	0.622 (0.456 to 0.849)	**0.003**	0.791 (0.652 to 0.960)	0.017
	Neutral	1.073 (0.717 to 1.605)	0.731	0.796 (0.562 to 1.127)	0.198	0.754 (0.534 to 1.063)	0.107	0.831 (0.675 to 1.024)	0.082
	Disagree	1.029 (0.700 to 1.510)	0.886	0.638 (0.430 to 0.947)	0.026	0.516 (0.338 to 0.786)	**0.002**	0.701 (0.560 to 0.875)	**0.002**
	Strongly disagree	1.201 (0.737 to 1.959)	0.463	0.972 (0.462 to 2.070)	0.942	1.848 (0.712 to 5.030)	0.213	1.004 (0.710 to 1.424)	0.980
Most people who are overweight have put on weight because they exercise too little									
Vigorous	Agree	0.859 (0.614 to 1.201)	0.375	0.685 (0.497 to 0.942)	0.020	0.719 (0.528 to 0.977)	0.035	0.752 (0.626 to 0.904)	**0.002**
	Neutral	0.771 (0.526 to 1.128)	0.181	0.666 (0.474 to 0.934)	0.019	0.608 (0.426 to 0.867)	0.006	0.682 (0.555 to 0.837)	< **0.001**
	Disagree	0.667 (0.449 to 0.988)	0.043	0.573 (0.381 to 0.861)	0.007	0.695 (0.436 to 1.104)	0.124	0.636 (0.501 to 0.807)	< **0.001**
	Strongly disagree	0.979 (0.577 to 1.665)	0.937	1.162 (0.556 to 2.467)	0.691	0.684 (0.277 to 1.659)	0.402	0.915 (0.630 to 1.332)	0.642

Ordinal regression models adjusted for age group, gender and asset score. 'Country' included as an additional confounder in the combined models. Ref: Reference group. OR: odds ratio. 95% CI: 95% confidence interval. $P < 0.004$ shown in bold. Combined: all three countries.

Table 2: Associations between attitudes towards obesity policies (predictors) and physical activity (outcomes)

Physical activity	Ref: Strongly in favour	Kenya (*n* = 1 000)		South Africa (*n* = 1 000)		UK (*n* = 1 000)		Combined (*n* = 3 000)	
		OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*
Putting a tax on high-fat foods, which would increase the price of things like crisps and chocolate									
Vigorous	In favour	0.927 (0.646 to 1.329)	0.679	1.003 (0.713 to 1.410)	0.987	0.709 (0.492 to 1.020)	0.064	0.881 (0.719 to 1.078)	0.219
	Neutral	1.009 (0.691 to 1.473)	0.963	0.768 (0.549 to 1.073)	0.122	0.675 (0.470 to 0.967)	0.032	0.812 (0.662 to 0.995)	0.044
	Against	0.944 (0.665 to 1.340)	0.747	0.647 (0.453 to 0.925)	0.017	0.550 (0.371 to 0.814)	**0.003**	0.721 (0.586 to 0.887)	**0.002**
	Strongly against	0.750 (0.494 to 1.136)	0.174	0.954 (0.638 to 1.428)	0.819	0.559 (0.334 to 0.930)	0.026	0.763 (0.595 to 0.979)	0.033
Moderate	In favour	0.795 (0.553 to 1.143)	0.216	1.044 (0.749 to 1.456)	0.799	1.112 (0.773 to 1.600)	0.566	0.981 (0.802 to 1.200)	0.852
	Neutral	0.881 (0.604 to 1.286)	0.512	1.003 (0.715 to 1.406)	0.987	0.814 (0.569 to 1.166)	0.262	0.872 (0.712 to 1.069)	0.189
	Against	0.861 (0.606 to 1.224)	0.405	0.635 (0.444 to 0.905)	0.012	1.075 (0.728 to 1.588)	0.716	0.849 (0.690 to 1.045)	0.123
	Strongly against	0.659 (0.433 to 1.003)	0.052	0.786 (0.526 to 1.173)	0.238	0.573 (0.339 to 0.960)	0.036	0.686 (0.534 to 0.881)	**0.003**
Putting a tax on sugary fizzy drinks									
Vigorous	In favour	0.655 (0.458 to 0.936)	0.020	1.045 (0.755 to 1.448)	0.789	0.886 (0.637 to 1.232)	0.472	0.870 (0.717 to 1.056)	0.158
	Neutral	0.793 (0.543 to 1.158)	0.231	0.943 (0.673 to 1.321)	0.732	0.638 (0.447 to 0.910)	0.013	0.788 (0.642 to 0.966)	0.022
	Against	0.703 (0.487 to 1.012)	0.059	0.837 (0.584 to 1.199)	0.332	0.619 (0.423 to 0.905)	0.013	0.731 (0.593 to 0.901)	**0.003**
	Strongly against	0.661 (0.417 to 1.047)	0.078	0.889 (0.574 to 1.379)	0.600	0.702 (0.419 to 1.172)	0.177	0.764 (0.585 to 0.998)	0.048
Reducing the standard size of unhealthy snacks or drinks									
Vigorous	In favour	0.969 (0.712 to 1.318)	0.840	0.809 (0.595 to 1.098)	0.174	0.727 (0.517 to 1.022)	0.067	0.841 (0.701 to 1.008)	0.061
	Neutral	0.718 (0.509 to 1.013)	0.060	0.592 (0.422 to 0.831)	**0.002**	0.554 (0.391 to 0.786)	**0.001**	0.625 (0.513 to 0.761)	< **0.001**
	Against	0.861 (0.583 to 1.272)	0.451	0.667 (0.442 to 1.006)	0.053	0.731 (0.504 to 1.058)	0.097	0.768 (0.615 to 0.959)	0.020
	Strongly against	0.823 (0.477 to 1.422)	0.483	0.766 (0.469 to 1.251)	0.286	0.603 (0.364 to 0.994)	0.048	0.726 (0.542 to 0.973)	0.032
Providing many more free weight management courses for people who want to lose weight									
Moderate	In favour	0.933 (0.721 to 1.207)	0.597	1.024 (0.787 to 1.331)	0.861	0.972 (0.742 to 1.274)	0.838	0.978 (0.841 to 1.138)	0.773
	Neutral	0.887 (0.561 to 1.405)	0.608	0.845 (0.581 to 1.226)	0.375	0.631 (0.459 to 0.867)	0.005	0.733 (0.594 to 0.905)	< **0.004**
	Against	0.608 (0.297 to 1.244)	0.172	1.830 (0.814 to 4.215)	0.147	0.834 (0.478 to 1.449)	0.520	0.922 (0.627 to 1.356)	0.680
	Strongly against	1.083 (0.207 to 6.159)	0.924	1.371 (0.539 to 3.535)	0.507	1.275 (0.421 to 3.933)	0.665	1.295 (0.675 to 2.504)	0.437
Doing more to create or improve cycle paths and pavements to encourage people to be more active									
Moderate	In favour	0.938 (0.727 to 1.210)	0.621	0.933 (0.720 to 1.208)	0.598	0.818 (0.619 to 1.079)	0.155	0.900 (0.773 to 1.046)	0.170
	Neutral	0.773 (0.531 to 1.126)	0.180	0.817 (0.584 to 1.141)	0.236	0.551 (0.404 to 0.748)	< **0.001**	0.683 (0.563 to 0.827)	< **0.001**
	Against	1.054 (0.476 to 2.356)	0.897	1.344 (0.601 to 3.039)	0.472	0.451 (0.247 to 0.811)	0.008	0.758 (0.506 to 1.134)	0.177
	Strongly against	0.777 (0.186 to 3.418)	0.727	2.885 (1.008 to 8.930)	0.053	0.652 (0.272 to 1.532)	0.327	1.134 (0.620 to 2.084)	0.682

(*Continued*)

Table 2: Continued.

Physical activity	Ref: Strongly in favour	Kenya ($n = 1\,000$)		South Africa ($n = 1\,000$)		UK ($n = 1\,000$)		Combined ($n = 3\,000$)	
		OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*
Walking	In favour	0.775 (0.598 to 1.004)	0.054	0.875 (0.675 to 1.135)	0.314	0.627 (0.473 to 0.832)	**0.001**	0.759 (0.652 to 0.885)	< **0.001**
	Neutral	1.124 (0.760 to 1.675)	0.560	0.735 (0.529 to 1.022)	0.068	0.540 (0.397 to 0.734)	< **0.001**	0.714 (0.590 to 0.866)	**0.001**
	Against	0.481 (0.219 to 1.058)	0.066	0.586 (0.270 to 1.261)	0.171	0.561 (0.319 to 0.986)	0.044	0.556 (0.377 to 0.820)	**0.003**
	Strongly against	0.587 (0.115 to 3.246)	0.516	0.531 (0.176 to 1.555)	0.249	0.385 (0.167 to 0.869)	0.022	0.481 (0.263 to 0.874)	0.017
Raising taxes on fuel and parking to encourage people to walk and cycle more									
Vigorous	In favour	0.807 (0.507 to 1.284)	0.366	0.907 (0.587 to 1.399)	0.658	0.693 (0.450 to 1.066)	0.096	0.800 (0.620 to 1.032)	0.086
	Neutral	0.782 (0.507 to 1.206)	0.267	0.649 (0.445 to 0.946)	0.025	0.498 (0.336 to 0.736)	< **0.001**	0.620 (0.492 to 0.780)	< **0.001**
	Against	0.719 (0.487 to 1.060)	0.097	0.669 (0.454 to 0.983)	0.041	0.633 (0.426 to 0.941)	0.024	0.679 (0.543 to 0.848)	**0.001**
	Strongly against	0.568 (0.375 to 0.858)	0.007	0.583 (0.398 to 0.852)	0.005	0.666 (0.443 to 0.997)	0.049	0.611 (0.486 to 0.768)	< **0.001**
Moderate	In favour	1.085 (0.682 to 1.725)	0.732	0.956 (0.626 to 1.459)	0.833	0.616 (0.400 to 0.947)	0.027	0.842 (0.655 to 1.083)	0.181
	Neutral	0.929 (0.605 to 1.424)	0.735	0.717 (0.495 to 1.037)	0.078	0.532 (0.361 to 0.783)	**0.001**	0.685 (0.546 to 0.858)	**0.001**
	Against	0.886 (0.602 to 1.302)	0.538	0.821 (0.561 to 1.199)	0.307	0.788 (0.531 to 1.169)	0.238	0.811 (0.650 to 1.011)	0.062
	Strongly against	0.682 (0.453 to 1.024)	0.066	0.563 (0.387 to 0.818)	**0.003**	0.676 (0.451 to 1.012)	0.058	0.625 (0.498 to 0.784)	< **0.001**

Ordinal regression models adjusted for age group, gender and asset score. 'Country' included as an additional confounder in the combined models. Ref: reference group. OR: odds ratio. 95% CI: 95% confidence interval. $P < 0.004$ shown in bold.

Mediating effects of beliefs concerning obesity on the relationship between nutrition knowledge and physical activity

Table 4 indicates the total, direct and indirect effects of DRKS (predictor) on PA (outcome) with beliefs concerning obesity as mediators. There was not sufficient evidence to suggest that the associations between nutrition knowledge and PA were mediated by beliefs concerning obesity when the respondents were stratified by country (all $p > 0.050$). However, in the combined sample, the association between nutrition knowledge and vigorous PA was partially mediated by the belief that 'Being overweight is something you inherit from your parents' (11.1% mediated). Again, in the combined sample, the association between nutrition knowledge and vigorous PA was fully mediated by the belief that 'Most people who are overweight have put on weight because they exercise too little' (11.1% mediated).

Mediating effects of attitudes towards obesity policies on the relationship between nutrition knowledge and physical activity

Table 5 lists the total, direct and indirect effects of nutrition knowledge (predictor) on PA (outcome) with attitudes towards obesity policies as mediators. There was no strong evidence to suggest that attitudes towards obesity had a mediation effect in Kenya and SA. In Kenya, a mediation effect by the statement 'Raising taxes on fuel and parking to encourage people to walk and cycle more' on the association between nutrition knowledge and vigorous PA was inconsistent. Likewise, in SA, an inconsistent mediation was observed in the statement 'Doing more to create or improve cycle paths and pavements to encourage people to be more active' on the association between nutrition knowledge and walking.

Table 3: Association between dietary recommendation knowledge (predictor) and physical activity (outcome)

Physical activity	Kenya ($n = 1\,000$)		South Africa ($n = 1\,000$)		UK ($n = 1\,000$)		Combined ($n = 3\,000$)	
	OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*
Vigorous	1.032 (0.982 to 1.084)	0.213	1.086 (1.038 to 1.137)	< **0.001**	0.993 (0.961 to 1.027)	0.692	1.026 (1.002 to 1.050)	**0.035**
Moderate	0.992 (0.944 to 1.041)	0.737	1.037 (0.992 to 1.084)	0.111	1.043 (1.009 to 1.078)	**0.012**	1.029 (1.006 to 1.053)	**0.015**
Walking	1.034 (0.984 to 1.086)	0.183	0.998 (0.954 to 1.044)	0.921	1.115 (1.078 to 1.154)	< **0.001**	1.068 (1.044 to 1.094)	< **0.001**

Ordinal regression models adjusted for age group, gender and asset score. 'Country' included as an additional confounder in the combined models. Ref: reference group. OR: odds ratio. 95% CI: 95% confidence interval. $P < 0.050$ shown in bold. Combined: all three countries.

Table 4: Total, direct and indirect effects of dietary recommendation knowledge score (predictor) on physical activity (outcome), with beliefs concerning obesity as mediators

			Total effects (Path c)		Direct effects (Path c')		Indirect effects (αβ: Product of paths α and β)	
Mediator	**Outcome**	**Country**	**Estimate (95% CI)**	***p***	**Estimate (95% CI)**	***p***	**Estimate (95% CI)**	***p***
There is no reason to worry about being a bit overweight	Vigorous	Kenya	0.013 (−0.005 to 0.032)	0.158	0.013 (−0.006 to 0.032)	0.186	0.001 (−0.001 to 0.003)	0.483
		South Africa	0.034 (0.016 to 0.052)	**< 0.001**	0.034 (0.016 to 0.052)	**< 0.001**	0.000 (−0.003 to 0.002)	0.835
		UK	−0.003 (−0.016 to 0.011)	0.689	−0.002 (−0.016 to 0.012)	0.799	−0.001 (−0.004 to 0.002)	0.460
		Combined	0.009 (0.000 to 0.018)	**0.046**	0.009 (0.000 to 0.018)	**0.048**	0.000 (−0.001 to 0.001)	1.000
	Moderate	Kenya	−0.002 (−0.022 to 0.017)	0.800	−0.003 (−0.022 to 0.017)	0.800	0.000 (−0.002 to 0.002)	0.993
		South Africa	0.015 (−0.003 to 0.034)	0.110	0.017 (−0.001 to 0.036)	0.071	−0.002 (−0.005 to 0.001)	0.128
		UK	0.018 (0.003 to 0.032)	**0.016**	0.019 (0.004 to 0.033)	**0.012**	−0.001 (−0.004 to 0.002)	0.453
		Combined	0.013 (0.004 to 0.023)	**0.006**	0.014 (0.005 to 0.024)	**0.003**	−0.001 (−0.002 to 0.000)	0.117
Being overweight is something you inherit from your parents	Vigorous	Kenya	0.013 (−0.005 to 0.032)	0.158	0.013 (−0.005 to 0.032)	0.161	0.000 (−0.001 to 0.001)	0.823
		South Africa	0.034 (0.016 to 0.052)	**< 0.001**	0.035 (0.016 to 0.053)	**< 0.001**	−0.001 (−0.002 to 0.001)	0.328
		UK	−0.003 (−0.016 to 0.011)	0.689	−0.001 (−0.015 to 0.013)	0.911	−0.002 (−0.005 to 0.001)	0.243
		Combined	0.009 (0.000 to 0.018)	**0.046**	0.010 (0.001 to 0.020)	**0.024**	−0.001 (−0.003 to 0.000)	**0.049**
Most overweight people have put on weight because of low metabolism	Vigorous	Kenya	0.013 (−0.005 to 0.032)	0.158	0.013 (−0.006 to 0.031)	0.185	0.001 (−0.001 to 0.002)	0.341
		South Africa	0.034 (0.016 to 0.052)	**< 0.001**	0.034 (0.016 to 0.052)	**< 0.001**	0.000 (−0.001 to 0.001)	0.754
		UK	−0.003 (−0.016 to 0.011)	0.689	0.000 (−0.014 to 0.014)	0.994	−0.003 (−0.007 to 0.001)	0.153
		Combined	0.009 (0.000 to 0.018)	**0.046**	0.010 (0.001 to 0.019)	**0.029**	−0.001 (−0.002 to 0.000)	0.076
Most people who are overweight have put on weight because they exercise too little	Vigorous	Kenya	0.013 (−0.005 to 0.032)	0.158	0.012 (−0.006 to 0.031)	0.193	0.001 (−0.001 to 0.003)	0.243
		South Africa	0.034 (0.016 to 0.052)	**< 0.001**	0.033 (0.014 to 0.051)	**< 0.001**	0.001 (−0.001 to 0.003)	0.180
		UK	−0.003 (−0.016 to 0.011)	0.689	−0.004 (−0.017 to 0.010)	0.601	0.001 (−0.001 to 0.002)	0.270
		Combined	0.009 (0.000 to 0.018)	**0.046**	0.008 (−0.001 to 0.017)	0.077	0.001 (0.000 to 0.002)	**0.025**

All structural equation models were adjusted for gender and asset score. 'Country' was included as an additional confounder in the combined models. UK: United Kingdom. 95% CI: 95% confidence interval. $P < 0.050$ shown in bold. Combined: all three countries.

The association between nutrition knowledge and moderate PA was fully mediated by attitudes towards 'Doing more to create or improve cycle paths and pavements to encourage people to be more active' in the UK sample (38.9% mediated), but this mediation was partial in the combined sample (23.1% mediated). Attitudes towards the same statement also partially mediated the association between nutrition knowledge and walking in both the UK and combined samples (12.8% and 13.3% mediated, respectively). Only in the combined sample were the associations of nutrition knowledge with both vigorous and moderate PA partially mediated by attitudes towards 'Raising taxes on fuel and parking to

Table 5: Total, direct and indirect effects of dietary recommendation knowledge score (predictor) on physical activity (outcome), with attitudes towards obesity as mediators

			Total effects (Path c)		Direct effects (Path c′)		Indirect effects (αβ: Product of paths α and β)	
Mediator	**Outcome**	**Country**	**Estimate (95% CI)**	***p***	**Estimate (95% CI)**	***p***	**Estimate (95% CI)**	***p***
Putting a tax on high fat foods, which would increase the price of things like crisps and chocolate	Vigorous	Kenya	0.013 (−0.005 to 0.032)	0.158	0.012 (−0.006 to 0.031)	0.197	0.001 (−0.001 to 0.003)	0.306
		South Africa	0.034 (0.016 to 0.052)	**< 0.001**	0.033 (0.015 to 0.051)	**< 0.001**	0.000 (−0.001 to 0.001)	0.476
		UK	−0.003 (−0.016 to 0.011)	0.689	−0.002 (−0.015 to 0.012)	0.789	−0.001 (−0.003 to 0.001)	0.270
		Combined	0.009 (0.000 to 0.018)	**0.046**	0.009 (0.000 to 0.018)	0.052	0.000 (0.000 to 0.001)	0.462
	Moderate	Kenya	−0.002 (−0.022 to 0.017)	0.800	−0.004 (−0.024 to 0.015)	0.668	0.002 (−0.001 to 0.004)	0.140
		South Africa	0.015 (−0.003 to 0.034)	0.110	0.015 (−0.004 to 0.033)	0.126	0.001 (−0.001 to 0.002)	0.437
		UK	0.018 (0.003 to 0.032)	**0.016**	0.018 (0.004 to 0.033)	**0.012**	−0.001 (−0.002 to 0.001)	0.321
		Combined	0.013 (0.004 to 0.023)	**0.006**	0.013 (0.004 to 0.022)	**0.007**	0.000 (0.000 to 0.001)	0.464
Putting a tax on sugary fizzy drinks	Vigorous	Kenya	0.013 (−0.005 to 0.032)	0.158	0.012 (−0.007 to 0.031)	0.212	0.002 (−0.001 to 0.004)	0.170
		South Africa	0.034 (0.016 to 0.052)	**< 0.001**	0.033 (0.015 to 0.051)	**< 0.001**	0.000 (−0.001 to 0.002)	0.552
		UK	−0.003 (−0.016 to 0.011)	0.689	−0.003 (−0.016 to 0.011)	0.718	0.000 (−0.002 to 0.001)	0.695
		Combined	0.009 (0.000 to 0.018)	**0.046**	0.009 (0.000 to 0.018)	0.061	0.001 (0.000 to 0.001)	0.108
Reducing the standard size of unhealthy snacks or drinks	Vigorous	Kenya	0.013 (−0.005 to 0.032)	0.158	0.013 (−0.006 to 0.031)	0.186	0.001 (−0.001 to 0.002)	0.253
		South Africa	0.034 (0.016 to 0.052)	**< 0.001**	0.032 (0.013 to 0.050)	**0.001**	0.002 (0.000 to 0.005)	0.079
		UK	−0.003 (−0.016 to 0.011)	0.689	−0.002 (−0.016 to 0.011)	0.730	0.000 (−0.002 to 0.001)	0.533
		Combined	0.009 (0.000 to 0.018)	**0.046**	0.009 (0.000 to 0.018)	0.062	0.001 (0.000 to 0.001)	0.126
Providing many more free weight management courses for people who want to lose weight	Moderate	Kenya	−0.002 (−0.022 to 0.017)	0.800	−0.004 (−0.023 to 0.016)	0.709	0.001 (−0.002 to 0.004)	0.410
		South Africa	0.015 (−0.003 to 0.034)	0.110	0.016 (−0.003 to 0.035)	0.097	−0.001 (−0.005 to 0.003)	0.645
		UK	0.018 (0.003 to 0.032)	**0.016**	0.015 (0.000 to 0.030)	**0.043**	0.003 (−0.001 to 0.006)	0.160
		Combined	0.013 (0.004 to 0.023)	**0.006**	0.012 (0.003 to 0.022)	**0.013**	0.001 (−0.001 to 0.003)	0.291
Doing more to create or improve cycle paths and pavements to encourage people to be more active	Moderate	Kenya	−0.002 (−0.022 to 0.017)	0.800	−0.004 (−0.024 to 0.015)	0.683	0.002 (−0.001 to 0.005)	0.294
		South Africa	0.015 (−0.003 to 0.034)	0.110	0.016 (−0.003 to 0.035)	0.107	0.000 (−0.004 to 0.003)	0.810
		UK	0.018 (0.003 to 0.032)	**0.016**	0.011 (−0.004 to 0.025)	0.156	0.007 (0.003 to 0.012)	**0.002**
		Combined	0.013 (0.004 to 0.023)	**0.006**	0.011 (0.001 to 0.020)	**0.032**	0.003 (0.001 to 0.005)	**0.011**
	Walking	Kenya	0.012 (−0.008 to 0.032)	0.239	0.010 (−0.010 to 0.030)	0.327	0.002 (−0.001 to 0.005)	0.206

(*Continued*)

Table 5: Continued.

Mediator	Outcome	Country	Total effects (Path c)		Direct effects (Path c′)		Indirect effects (αβ: Product of paths α and β)	
			Estimate (95% CI)	*p*	Estimate (95% CI)	*p*	Estimate (95% CI)	*p*
		South Africa	0.000 (−0.018 to 0.019)	0.994	−0.005 (−0.023 to 0.014)	0.639	0.005 (0.000 to 0.009)	**0.039**
		UK	0.047 (0.031 to 0.063)	**< 0.001**	0.041 (0.025 to 0.057)	**< 0.001**	0.006 (0.002 to 0.011)	**0.008**
		Combined	0.030 (0.020 to 0.040)	**< 0.001**	0.026 (0.016 to 0.036)	**< 0.001**	0.004 (0.002 to 0.006)	**0.001**
Raising taxes on fuel and parking to encourage people to walk and cycle more	Vigorous	Kenya	0.013 (−0.005 to 0.032)	0.158	0.011 (−0.008 to 0.029)	0.253	0.003 (0.000 to 0.005)	**0.047**
		South Africa	0.034 (0.016 to 0.052)	**< 0.001**	0.033 (0.015 to 0.051)	**< 0.001**	0.000 (−0.002 to 0.002)	0.780
		UK	−0.003 (−0.016 to 0.011)	0.689	−0.001 (−0.015 to 0.013)	0.888	−0.002 (−0.004 to 0.001)	0.185
		Combined	0.009 (0.000 to 0.018)	**0.046**	0.010 (0.001 to 0.019)	**0.027**	−0.001 (−0.002 to 0.000)	**0.039**
	Moderate	Kenya	−0.002 (−0.022 to 0.017)	0.800	−0.005 (−0.024 to 0.014)	0.622	0.002 (0.000 to 0.005)	0.065
		South Africa	0.015 (−0.003 to 0.034)	0.110	0.015 (−0.004 to 0.033)	0.115	0.000 (−0.002 to 0.002)	0.780
		UK	0.018 (0.003 to 0.032)	**0.016**	0.019 (0.005 to 0.034)	**0.009**	−0.002 (−0.004 to 0.001)	0.224
		Combined	0.013 (0.004 to 0.023)	**0.006**	0.014 (0.005 to 0.024)	**0.003**	−0.001 (−0.002 to 0.000)	**0.047**

All structural equation models were adjusted for gender and asset score. 'Country' was included as an additional confounder in the combined models. UK: United Kingdom. 95% CI: 95% confidence interval. $P < 0.050$ shown in bold. Combined: all three countries. Full mediation was present when the total (path c) and indirect effects (αβ) were significant ($p < 0.050$), but the direct effect (path c′) was not ($p > 0.050$). Partial mediation was observed when the total and indirect effects were significant, and the direct effect also remained significant ($p < 0.050$). Inconsistent mediation was present when neither total nor direct effect was significant ($p > 0.050$) but indirect effect was significant ($p < 0.050$).

encourage people to walk and cycle more' (11.1% and 7.7% mediated, respectively).

Discussion

Previous studies have investigated the relationships between nutrition knowledge and nutrition-related attitudes and dietary intake.[11,12] However, evidence of the influence of nutrition knowledge on obesity-related attitudes and PA behaviour is limited. In the present study, we assessed associations between nutrition knowledge and obesity-related attitudes and PA among 3 000 young adults (18–35-year-olds) from Kenya, SA and the UK. Findings from previous studies suggested that nutrition knowledge was more strongly associated with nutrition-related attitudes compared with dietary intake,[12–14] supporting the hypothesis that the relationship between knowledge and behaviour may be mediated by attitudes. Against this background, we hypothesised that better nutrition knowledge was associated with higher PA and that this relationship was mediated by obesity-related attitudes.

Overall, our study sample comprised young men and women with good nutrition knowledge (average DRKS = 11 out of 18) who were physically active (3 out of 7 days of vigorous PA on average). Furthermore, some 55% of the respondents were aware that being overweight is a problem. These observations follow the literature, which has consistently demonstrated that 18–35-year-olds have good nutrition knowledge when tested[18] and are often involved in some form of PA,[19] and their willingness to lose weight is often motivated by health reasons.[20]

In the present study, we went further and provided evidence that nutrition knowledge was often associated with obesity-related attitudes and reported PA behaviour among young adults. However, the strength and directions of the association were sometimes dependent on the country, with most of the country-specific associations seen when comparing the HIC (UK) with the LMICs (SA and Kenya). Further, the evidence of associations between obesity-related attitudes and PA was inconsistent and sometimes seen only in the UK, but more often only observed when the countries were combined. A similar case of weak evidence was observed for the mediation effects of obesity-related attitudes on the relationship between nutrition knowledge and PA. Overall, findings from the present study suggested that nutrition knowledge is associated with both obesity-related attitudes and PA behaviour among young adults. Our findings also provided evidence that the relationship between nutrition knowledge and PA was sometimes mediated by obesity-related attitudes.

Nutrition knowledge is associated with obesity-related attitudes and physical activity

Certainly, previous European studies had suggested that better nutrition knowledge was often associated with higher levels of

PA in many participants, ranging from highly active young sports players[21] to less active elderly people.[22] However, there has been a dearth of studies that assessed this relationship in countries at different levels of economic development. In the present study, we have confirmed that nutrition knowledge is positively associated with reported PA among young adults, particularly those from SA and the UK. Our findings also highlighted the importance of testing such relationships in less developed countries, as the relationship between nutrition knowledge and PA was not observed at all in Kenya. Based on findings from the present study, it is possible that the lack of evidence of association in Kenya was because of lower nutrition knowledge but higher PA in respondents from that country when compared with SA and the UK. Previous studies have suggested that, due to differences in access to knowledge, participants from developing countries such as Kenya generally showed low to moderate nutrition knowledge,[23] while those from developed nations, for example the UK, often scored well in nutrition knowledge tests.[16] In contrast, other findings have suggested that participants from Kenya were more physically active compared with those from developed nations, because higher urbanisation levels lead to less PA and more sedentary behaviour.[24]

To the best of our knowledge, this is the first study to show that nutrition knowledge is associated with obesity-related attitudes among young adults. One of the interesting observations from the present study was that better nutritional knowledge was associated with being less likely to believe that obesity is not a problem. Such observation follows previous studies, which have suggested that better nutrition knowledge was associated with the tendency to want to eat healthily and maintain a healthy bodyweight status.[25] Based on those previously reported observations and the current findings from our study, people who have higher nutrition knowledge may be more likely to be physically active and have the desire to learn more about the consequences of being overweight and obese. However, experimental studies that include evaluation of the effects of increasing nutrition knowledge on health-related attitudes are required to fully test this hypothesis.

Although good nutrition knowledge and awareness regarding obesity were evident in the present study, there was also a high prevalence of weight bias – the negative ideologies associated with overweight and obesity.[26] For example, we found that a greater proportion of the participants believed that being overweight is not attributed to inheritance, but rather low metabolism, as well as not exercising enough and eating too much. This finding corresponds to previous studies, which have consistently shown that weight bias is a major problem among young adults.[27] Adding to this, we demonstrated that better nutrition knowledge was generally linked to agreeing with statements of weight bias. For example, better nutrition knowledge was associated with greater odds of believing that obesity is primarily caused by factors within the individual's control, particularly not exercising enough. Corresponding to this observation, we also demonstrated that better nutrition knowledge was associated with lower odds of believing that obesity is caused by factors outside of an individual's control (genetics and low metabolism). Future public interventions aimed at improving general nutrition knowledge must be accompanied by efforts to reduce weight bias, such as increasing awareness of the complex causes of excess weight gain.

With regard to obesity policies, we observed that a greater proportion of the respondents generally favoured obesity-related policies. This finding is in accordance with previous studies, which have consistently suggested that obesity policies often receive high support from the general public.[5] Also corresponding to previous studies,[5] we found that there was more support for policies involving government-funded healthy lifestyle campaigns than policies that encourage increasing taxes on unhealthy foods and fuel. Adding to this knowledge, our findings suggested that better nutrition knowledge was associated with favouring most obesity policies. We found strong evidence that better nutrition knowledge was associated with favouring the provision of free weight management courses, creating or improving cycle paths, and banning adverts for high fat foods. Hence, it is likely that public interventions aimed at increasing nutrition knowledge may lead to improved acceptance of proposed health-related policies as a result of improved overall health knowledge.

Mediation effects of obesity-related attitudes

In the present study, the associations between obesity-related attitudes and PA were weak and limited to only particular attitudes and types of PA. Nevertheless, mediation analysis suggested that some particular attitudes had significant mediation effects on the relationship between nutrition knowledge and PA, providing some evidence to support our proposed hypothesis. On one hand, our findings demonstrated that believing that obesity is primarily caused by inheritance and not exercising enough both mediate the association between nutrition knowledge and vigorous PA. Although these mediation effects were relatively weak and only present when the countries were combined, they did provide some evidence that supported our hypothesis that 'better nutrition knowledge was associated with higher PA, and that this relationship was mediated by obesity-related attitudes'. Furthermore, our hypothesis was also supported by evidence of mediation effects of attitudes towards two obesity policies in particular, 'Doing more to create or improve cycle paths and pavements to encourage people to be more active' and 'Raising taxes on fuel and parking to encourage people to walk and cycle more'.

Although previous KAP studies related to diet and nutrition have shown that health knowledge, attitudes and practices are often interlinked, mediation analyses were often not tested.[11, 12] Based on the present study, future research that aims to assess the role of nutrition education in health behaviour should also assess obesity-related attitudes. This is of particular importance because although the relationships between nutrition knowledge and PA behaviour were weak, the effectiveness of public health interventions may sometimes be confounded by public attitudes.

In this study, many of the associations were only observed when the three countries were combined, reflecting the low strength of those associations. What was even more interesting in the present study was that no associations between obesity-related attitudes and PA were observed at all in Kenya. This observation is key because health intervention frameworks that are employed in LMICs are often based on findings from HICs.

Study limitations

Although we have shown that better nutrition knowledge is associated with obesity-related attitudes, as well as higher PA, there was only weak evidence of mediation by the obesity-

related attitudes. This study was cross-sectional, and we have not proved any causal links in the observed relationships. It is possible that other socioeconomic and sociocultural factors that were not included in the present study may have partly influenced our findings. One of the limiting key factors that was not measured in the present study is the level of education, which may have strongly influenced general nutrition knowledge.[8] Future studies should investigate the role of education level in the observed associations. Certainly, experimental studies, including randomised controlled trials and longitudinal analyses, would provide better evidence of the impact of nutritional knowledge on the tested outcomes. We found that many of the observed relationships were country dependent, with the UK occasionally showing a stronger and opposite direction compared with Kenya and SA. We recommend that future multi-country studies assessing the impact of nutrition knowledge on obesity-related attitudes and PA should stratify the analyses by country, as we have in the present study. Another caveat is that our study design included only young adults between 18 and 35 years of age, and the translation of the findings to an older age group is thus not known. To confirm the observed associations, this study should be repeated with a larger sample size that also includes other countries and older age groups. It would also be interesting to see whether any work could be done to elucidate a mechanism that explains the links between nutrition knowledge and tested outcomes, perhaps by carrying out studies with smaller sample sizes that would allow detailed psychometric measurements in a longitudinal setting. Furthermore, although the GNK questionnaire that we used in this study has been successfully validated in several countries, at different levels of economic development, including the UK, China, Australia, and Uganda,[16,28,29] we are not aware of any study that has validated this tool in Kenya and South Africa. Therefore, interpretation of our findings should be based on the overall differences observed across the three countries at different levels of economic developments.

Conclusions

We have shown that nutrition knowledge is associated with obesity-related attitudes, including beliefs concerning obesity and attitudes towards obesity policies in young adults from different sociodeveloped countries. Importantly here, our findings suggest an increase in nutrition knowledge to be associated with an increase in the tendency to believe statements of weight bias. The findings highlight the importance of public interventions that aim to increase health knowledge for effective implementation of related policies. However, to facilitate the acceptance of policy action, health education interventions should be accompanied by campaigns that also improve the awareness of multiple causes of obesity and reduce the potential weight bias associated with increased health knowledge.

We have also demonstrated that although better nutrition knowledge was often associated with higher PA behaviour, this relationship was rarely mediated by obesity-related attitudes. Nevertheless, our findings strongly suggest that many of the relationships between nutrition knowledge and obesity-related attitudes and PA behaviour are dependent on the country, with many of the associations observed in the UK – the country at highest level of economic development but not observed in Kenya – the country with the lowest level of economic development. Therefore, public health interventions that are based on findings from HIC should be carefully evaluated in LMIC before they are implemented in low-resource settings.

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References

1. Schwartz LN, Shaffer JD, Bukhman G. The origins of the 4 × 4 framework for noncommunicable disease at the World Health Organization. SSM Popul Health. 2021;13:100731. https://doi.org/10.1016/j.ssmph.2021.100731
2. Ng R, Sutradhar R, Yao Z, et al. Smoking, drinking, diet and physical activity-modifiable lifestyle risk factors and their associations with age to first chronic disease. Int J Epidemiol. 2020;49:113–130. https://doi.org/10.1093/ije/dyz078
3. Popkin BM, Ng SW. The nutrition transition to a stage of high obesity and noncommunicable disease prevalence dominated by ultra-processed foods is not inevitable. Obes Rev. 2022;23:e13366. https://doi.org/10.1111/obr.13366
4. Rajah R, Hassali MAA, Murugiah MK. A systematic review of the prevalence of limited health literacy in Southeast Asian countries. Public Health. 2019;167:8–15. https://doi.org/10.1016/j.puhe.2018.09.028
5. Beeken RJ, Wardle J. Public beliefs about the causes of obesity and attitudes towards policy initiatives in Great Britain. Public Health Nutr. 2013;16:2132–2137. https://doi.org/10.1017/S1368980013001821
6. Wang C, Coups EJ. Causal beliefs about obesity and associated health behaviors: results from a population-based survey. Int J Behav Nutr Phys Act. 2010;7:article 19. https://doi.org/10.1186/1479-5868-7-19.
7. Knerr S, Ceballos RM, Chan KCG, et al. Women's beliefs about what causes obesity: variation by race/ethnicity and acculturation in a Washington state sample. Ethn Health. 2020;25:243–254. https://doi.org/10.1080/13557858.2017.1414156
8. Curtice J. Attitudes to obesity: findings from the 2015 British social attitudes survey. NatCen Social Research, London, United Kingdom, 2016. http://www.bsa.natcen.ac.uk/media/39132/attitudes-to-obesity.pdf
9. Luck-Sikorski C, Riedel-Heller SG, Phelan JC. Changing attitudes towards obesity – results from a survey experiment. BMC Public Health. 2017;17:373. https://doi.org/10.1186/s12889-017-4275-y.
10. Hendrie G, Coveney J, Cox D. Exploring nutrition knowledge and the demographic variation in knowledge levels in an Australian community sample. Public Health Nutr. 2008;11:1365–1371. https://doi.org/10.1017/S1368980008003042
11. Bakhtiar M, Masud-Ur-Rahman M, Kamruzzaman M, et al. Determinants of nutrition knowledge, attitude and practices of adolescent sports trainee: A cross-sectional study in Bangladesh. Heliyon. 2021;7:e06637. https://doi.org/10.1016/j.heliyon.2021.e06637

12. Jezewska-Zychowicz M, Plichta M. Diet quality, dieting, attitudes and nutrition knowledge: their relationship in Polish young adults-a cross-sectional study. Int J Environ Res Public Health. 2022;19:6533. https://doi.org/10.3390/ijerph19116533
13. Bhuiyan FR, Barua JL, Kalam KA. Knowledge, attitude and practices regarding nutrition among adolescent girls in Dhaka city: a cross-sectional study. Nutr Food Sci Int J. 2021;10:555795. https://doi.org/10.19080/NFSIJ.2021.10.555795.
14. Nomasonto X, Chinyamurindi WT, Shava H. The relationship between healthy eating attitudes and nutritional knowledge among young consumers. J Consum Sci. 2020;17:373.
15. Mtintsilana A, Craig A, Mapanga W, et al. Association between socio-economic status and non-communicable disease risk in young adults from Kenya, South Africa, and the United Kingdom. Sci Rep. 2023;13:728. https://doi.org/10.1038/s41598-023-28013-4
16. Kliemann N, Wardle J, Johnson F, et al. Reliability and validity of a revised version of the General Nutrition Knowledge Questionnaire. Eur J Clin Nutr. 2016;70:1174–1180. https://doi.org/10.1038/ejcn.2016.87
17. World Health Organization. Physical Activity. https://www.who.int/news-room/fact-sheets/detail/physical-activity (accessed 25 January 2023).
18. Barbosa LB, Vasconcelos SML, Correia LO dos S, et al. Nutrition knowledge assessment studies in adults: a systematic review. Cien Saude Colet. 2016;21:449–462. https://doi.org/10.1590/1413-81232015212.20182014
19. Towne SD, Ori MG, Smith ML, et al. Accessing physical activity among young adults attending a university: the role of sex, race/ethnicity, technology use, and sleep. BMC Public Health. 2017;17:721. https://doi.org/10.1186/s12889-017-4757-y
20. Lanoye A, Gorin AA, LaRose JG. Young adults' attitudes and perceptions of obesity and weight management: implications for treatment development. Curr Obes Rep. 2016;5:14–22. https://doi.org/10.1007/s13679-016-0188-9
21. Nikolaidis PT, Theodoropoulou E. Relationship between nutrition knowledge and physical fitness in semiprofessional soccer players. Scientifica (Cairo). 2014;2014:180353. https://doi.org/10.1155/2014/180353
22. Jeruszka-Bielak M, Kollajtis-Dolowy A, Santoro A, et al. Are nutrition-related knowledge and attitudes reflected in lifestyle and health among elderly people? A study across five European countries. Front Physiol. 2018;9:994. https://doi.org/10.3389/fphys.2018.00994
23. Perumal N, Cole DC, Ouédraogo HZ, et al. Health and nutrition knowledge, attitudes and practices of pregnant women attending and not-attending ANC clinics in western Kenya: a cross-sectional analysis. BMC Pregnancy Childbirth. 2013;13:146. https://doi.org/10.1186/1471-2393-13-146
24. Kidokoro T, Fuku N, Yanagiya T, et al. Physical activity and sedentary behaviour patterns among Kenyan and Japanese children: a comprehensive cross-country comparison. Int J Environ Res Public Health. 2020;17:4254. https://doi.org/10.3390/ijerph17124254
25. Laz TH, Rahman M, Pohlmeier AM, et al. Level of nutrition knowledge and its association with weight loss behaviors among low-income reproductive-age women. J Community Health. 2015;40:542–548. https://doi.org/10.1007/s10900-014-9969-9
26. Papadopoulos S, Brennan L. Correlates of weight stigma in adults with overweight and obesity: a systematic literature review. Obesity. 2015;23:1743–1760. https://doi.org/10.1002/oby.21187
27. Li C, Ademiluyi A, Ge Y, et al. Using social media to understand web-based social factors concerning obesity: systematic review. JMIR Public Heal Surveill. 2022;8:e25552. https://doi.org/10.2196/25552
28. Gao Z, Wu F, Lv G, et al. Development and validity of a general nutrition knowledge questionnaire (GNKQ) for Chinese adults. Nutrients. 2021;13:4353. https://doi.org/10.3390/nu13124353
29. Bukenya R, Ahmed A, Andrade JM, et al. Validity and reliability of general nutrition knowledge questionnaire for adults in Uganda. Nutrients. 2017;9:172. https://doi.org/10.3390/nu9020172

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