Appendix 1

Bazian

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Body mass index and waist circumference thresholds for intervening to prevent ill health among black, Asian and other minority ethnic groups in the UK

External evidence review

Evidence review for Public Health Guidance

Developed by Bazian for NICE

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About Bazian

Bazian specialises at evidence-based analysis and consulting to help NHS organisations and others. Our multidisciplinary team includes information specialists, health research analysts and clinicians with established strengths in applying evidence based methods to quantitative synthesis, health technology assessment, health services research, public health, health economics and modelling. Together we produce tailored outputs to tight timelines and to suit client needs.

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List of Abbreviations

ADA	American Diabetes Association
AUC	Area Under the Curve
BMI	Body Mass Index
BP	Blood Pressure
CFBG	Capillary Fasting Blood Glucose
CI	Confidence Interval
CRBG	Capillary Random Blood Glucose
CVD	CardioVascular Disease
DH	Department of Health
FBG	Fasting Blood Glucose
FBS	Fasting Blood Sugar
FPG	Fasting Plasma Glucose
HbA_1C	Glycated haemoglobin
HRQL	Health Related Quality of Life
HSE	Health Survey for England
IDF	International Diabetes Federation
NICE	The National Institute for Health and Clinical Excellence
OECD	Organisation for Economic Co-operation and Development
OGTT	Oral Glucose Tolerance Test
r	Correlation coefficient
ROC	Receiver Operating Characteristics
SES	SocioEconomic Status
S_n	Sensitivity
S_p	Specificity
UK	United Kingdom
WC	Waist Circumference
WHO	World Health Organization
WHR	Waist-to-Hip Ratio
WHtR	Waist-to-Height Ratio (also see WSR)
WSR	Waist to Stature [height] Ratio

1 Executive Summary

1.1 Background

Two anthropometric indices, body mass index (BMI) and waist circumference (WC) are commonly used to assess overweight and obesity for individuals and populations. Cut-off points are defined from studies of European-derived populations. However, these cut-offs may not be appropriate for other ethnic groups. The National Institute for Health and Clinical Excellence (NICE) has been asked by the Department of Health (DH) to develop public health guidance on assessing body mass index and waist circumference thresholds for intervening to prevent ill health and premature death among adults from black, Asian and other minority ethnic groups in the UK. This guidance will provide recommendations for good practice based on the best available evidence. It is aimed at commissioners, managers and practitioners with public health as part of their remit, working within the NHS, local authorities and the wider public, private, voluntary and community sectors. It may also be of interest to people from black, Asian and minority ethnic groups and other members of the public.

1.1 Aims and Objectives

This review aims to summarise the relevant empirical data that answers four specific questions related to the anthropometric indices in black, Asian and other minority ethnic groups resident in the UK compared with white European groups.

Question 1: How accurate are body mass index (BMI) and waist circumference in predicting the future risk of type 2 diabetes, fatal/non-fatal myocardial infarction or stroke and overall mortality among adults from black, Asian and other minority ethnic groups living in the UK compared to the white or general UK population?

Question 2: What are the BMI and waist circumference cut-off points indicating a healthy range for these measures among adults from different black, Asian and other minority ethnic groups living in the UK?

Question 3: What are the BMI and waist circumference cut-off points that indicate an increased risk of type 2 diabetes, fatal/non-fatal myocardial infarction and stroke and the need for preventative action among adults from different black, Asian and other minority ethnic groups living in the UK?

Question 4: What are the cut-off points for BMI and waist circumference among adults from black, Asian and other minority ethnic groups living in the UK that are 'risk equivalent' to the current thresholds set for white European populations?

Expected outcomes:

Anthropometric measures (that is, BMI or waist circumference) and the associated risk of type 2 diabetes and fatal/non-fatal myocardial infarction or stroke and overall mortality.

1.2 Methods

This systematic review was undertaken according to the general principles recommended in the methods guide for development of NICE public health guidance (2009). Methods followed the development of a review protocol and search protocol. The manual was also used to guide the development of the search methods. Citation searching and an expert call for additional evidence were both used to extend the studies included.

The search strategies were developed and conducted by NICE information specialists. Full text document retrieval was undertaken at NICE. For this review 872 unique studies were identified from database and other sources. Following a first sift at abstract level appraisal, 610 were screened at full text. Of these, 205 were assessed as suitable for inclusion by NICE based on expert advice. An adjusted criteria set, developed with in negotiation between NICE and Bazian, was used to further sift at full text. This final sifting was based on the following inclusion criteria:

- Population (Black African/Caribbean, South Asian, Middle Eastern, Hong Kong Chinese, mixed race)
- Exposures (BMI and/or WC measured)

- Outcomes (diabetes, stroke, fatal or non-fatal MI, mortality).
- Observational study designs (cohort or cross sectional studies)

Studies were excluded if they were not published in English or if their study design or analysis rendered them unsuitable for data extraction. As Chinese ethinic groups make up a small proportion of the total UK population (see Table 1), priority was given to those Chinese studies conducted in the UK, other Western countries or Hong Kong. As such, 39 studies with Chinese participants conducted in other non-Western countries were excluded. A total of 27 studies are included in this report. See Section 3.2 and Appendix 1 for a list of excluded studies and reason(s) for exlusion, and Appendix 2 for a list of excluded Chinese studies.

No studies were identified related to individuals of mixed ethnic origin; however, several studies pooled data on populations with multiple scoped ethnicities. These studies have been included, and are referred to using the term mixed ethnic populations throughout the review.

Each study was assessed using modified quality checklists described in the methods guide for the development of NICE public health guidance, and scored for validity and applicability (See Appendix 3 for Quality Appraisal Checklists).

Applicability of the evidence was assessed according to the methods for the development of NICE public health guidance.[1] Population setting, and outcome characteristics as outlined in the methods manual were considered, and the extent to which these factors aligned with the current review questions was assessed. In addition, the following characteristics were considered to be of particular relevance:

- Population: mean baseline BMI and/or WC
- Setting: UK or Western setting vs. non-Western setting
- Outcomes: diabetes diagnostic methods and criteria

See Section 3.4 for an overview of applicability assessment methods.

Study characteristics and data were extracted from the included studies by a research analyst and checked by a second analyst. The findings were synthesised narratively and used to generate evidence statements. The statements reflect the strength (quality, quantity and consistency) of the evidence and the applicability to black, Asian and minority ethnic groups in the UK.

1.3 Evidence Statements

Question 1

Black populations

Evidence statement Q1.1: BMI as predictor of diabetes risk in black populations

ROC analysis indicates that BMI can predict incident diabetes in black populations.

Q1.1.a: UK or Western Countries

Moderate evidence was found from one cohort study (MacKay, 2009 [quality +/ applicability +])[2] indicating that the predictive power (ROC AUC) of BMI for diabetes in black populations was 0.616 compared to 0.734 among white populations in the USA.

This study had moderate applicability to the UK.

Q1.1.b: Other Countries

Moderate evidence was found from one cohort study (Sargeant, 2002 [+/-])[3] that the predictive power (ROC AUC) of BMI for diabetes in black males was 0.74, and 0.62 in black females.

This study had weak applicability to the UK.

Evidence statement Q1.2: WC as predictor of diabetes risk in black populations

ROC analysis indicates that WC can predict incident diabetes in black populations.

Q1.2.a: UK or Western Countries

Moderate evidence was found from one cohort study (MacKay, 2009 [+/+])[2] indicating that the predictive power (ROC AUC) of WC for diabetes in black populations was 0.630 compared to 0.716 among white populations in the USA.

This study had moderate applicability to the UK.

Q1.2.b: Other Countries

Moderate evidence was found from one cohort study (Sargeant, 2002 [+/-])[3] that the predictive power (ROC AUC) of WC for diabetes in black males was 0.78, and 0.61 in black females.

This study had weak applicability to the UK.

No evidence – Black populations

Evidence statement Q1.3: BMI as predictor of myocardial infarction, stroke or mortality in black populations

No evidence was found relevant to BMI as a predictor of myocardial infarction, stroke or mortality in black populations.

Evidence statement Q1.4: WC as predictor of myocardial infarction, stroke or mortality in black populations

No evidence was found relevant to WC as a predictor of myocardial infarction, stroke or mortality in black populations.

South Asian populations

No evidence – South Asian populations

Evidence statement Q1.5: BMI as predictor of diabetes risk in South Asian populations

No evidence was found relevant to BMI as a predictor of diabetes in South Asian populations.

Evidence statement Q1.6: BMI as predictor of myocardial infarction, stroke or mortality in South Asian populations

No evidence was found relevant to BMI as a predictor of myocardial infarction, stroke or mortality in South Asian populations.

Evidence statement Q1.7: WC as predictor of diabetes risk in South Asian populations

No evidence was found relevant to WC as a predictor of diabetes in South Asian populations.

Evidence statement Q1.8: WC as predictor of myocardial infarction, stroke or mortality in South Asian populations

No evidence was found relevant to WC as a predictor of myocardial infarction, stroke or mortality in South Asian populations.

Middle Eastern populations

Evidence statement Q1.9: BMI as predictor of diabetes risk in Middle Eastern populations

In Middle Eastern populations, ROC analysis indicates that BMI can predict incident diabetes, and has an AUC ranging from approximately 0.61 to 0.69

Q1.9.a: UK or Western Countries

No evidence was found relevant to BMI as a predictor of diabetes in Middle Eastern populations in the UK or other western settings

Q1.9.b: Other Countries

Moderate to strong evidence was found from four cohort studies (Mansour, 2007 [++/+]),[4] (Hadaegh, 2006 [+/+]),[5] (Hadaegh, 2009 [+/+])[6] and (Janghorbani, 2009 [+/-])[7] that the predictive power (ROC AUC) of BMI for diabetes ranged from 0.61 to 0.69 in Middle Eastern populations.

These studies had weak to moderate applicability to the UK.

Evidence statement Q1.10: WC as predictor of diabetes risk in Middle Eastern populations

Q1.10.a: UK or Western Countries

No evidence was found relevant to WC as a predictor of diabetes in Middle Eastern populations in the UK or other western settings.

Q1.10.b: Other countries

Moderate to strong evidence was found from two cohort studies (Mansour, 2007 [++/+])[4] and (Janghorbani, 2009 [+/-])[7] that the predictive power (ROC AUC) of WC for incident diabetes ranged from 0.62 to 0.71 in Middle Eastern populations.

These studies had weak to moderate applicability to the UK.

No evidence – Middle Eastern populations

Evidence statement Q1.11: BMI as predictor of myocardial infarction, stroke or mortality in Middle Eastern populations

No evidence was found relevant to BMI as a predictor of myocardial infarction, stroke or mortality in Middle Eastern populations.

Evidence statement Q1.12: WC as predictor of myocardial infarction, stroke or mortality in Middle Eastern populations

No evidence was found relevant to WC as a predictor of myocardial infarction, stroke or mortality in Middle Eastern populations.

Chinese populations

No evidence – Chinese populations

Evidence statement Q1.13: BMI as predictor of diabetes risk in Chinese populations

No evidence was found relevant to BMI as a predictor of diabetes in Chinese populations.

Evidence statement Q1.14: BMI as predictor of myocardial infarction, stroke or mortality risk in Chinese populations

No evidence was found relevant to BMI as a predictor of myocardial infarction, stroke or mortality in Chinese populations.

Evidence statement Q1.15: WC as predictor of diabetes risk in Chinese populations
No evidence was found relevant to WC as a predictor of diabetes in Chinese populations.

Evidence statement Q1.16: WC as predictor of myocardial infarction, stroke or mortality risk in Chinese populations
No evidence was found relevant to WC as a predictor of myocardial infarction, stroke or mortality in Chinese populations.

Mixed Ethnic populations

No Evidence – Mixed ethnic populations

Evidence statement Q1.17: BMI as predictor of diabetes risk in mixed ethnic populations
No evidence was found relevant to BMI as a predictor of diabetes in mixed ethnic populations.

Evidence statement Q1.18: BMI as predictor of myocardial infarction, stroke or mortality risk in mixed ethnic populations
No evidence was found relevant to BMI as a predictor of myocardial infarction, stroke or mortality in mixed ethnic populations.

Evidence statement Q1.19: WC as predictor of diabetes risk in mixed ethnic populations
No evidence was found relevant to WC as a predictor of diabetes in mixed ethnic populations.

Evidence statement Q1.20: WC as predictor of myocardial infarction, stroke or mortality risk in mixed ethnic populations
No evidence was found relevant to WC as a predictor of myocardial infarction, stroke or mortality in mixed ethnic populations.

Question 2

Black populations

Evidence statement Q2.1: Healthy BMI cut-points for black populations (Type 2 Diabetes)

Moderate evidence from one cross sectional study (Taylor, 2010 [++/+])[8] suggests that 29.9 kg/m^2 may be an appropriate upper boundary for a healthy BMI range in black populations, compared to 24.9 kg/m^2 in white participants. No lower boundary was identified.

This study had moderate applicability to the UK.

No evidence – Black populations

Evidence statement Q2.2: Healthy BMI cut-points for black populations (myocardial infarction, stroke and mortality)

No evidence was found relevant to healthy BMI cut-points for myocardial infarction, stroke or mortality in black populations.

Evidence statement Q2.3: Healthy WC cut-points for black populations (Type 2 Diabetes)

No evidence was found relevant to healthy WC cut-points for diabetes in black populations.

Evidence statement Q2.4: Healthy WC cut-points for black populations (myocardial infarction, stroke and mortality)

No evidence was found relevant to healthy WC cut-points for myocardial infarction, stroke or mortality in black populations.

South Asian populations

Evidence statement Q2.5: Healthy BMI cut-points for South Asian populations (Type 2 Diabetes)

Q2.5.a: UK and Western Countries

No evidence was found relevant to healthy BMI cut-points for diabetes in South Asian populations in Western settings.

Q2.5.b: Other Countries

Weak evidence from one cross sectional study conducted in India (Snehalatha, 2003 [-/-])[9] suggest that 22.9 kg/m^2 may represent an appropriate upper boundary for a healthy population BMI range with regards to diabetes; no lower boundary was identified.

This study had weak applicability to the UK.

Evidence statement Q2.6: Healthy WC cut-points for South Asian populations (Type 2 Diabetes)

Q2.6.a: UK and Western Countries

No evidence was found relevant to healthy WC cut-points for type 2 diabetes in South Asian populations in the UK or other Western settings.

Q2.6.b: Other Countries

Weak evidence from one cross sectional study conducted in India (Snehalatha, 2003 [-/-])[9] suggests that a healthy population WC is less than 85 cm for South Asian men, and less than 80 cm for South Asian women.

This study had weak applicability to the UK.

No evidence – South Asian populations

Evidence statement Q2.7: Healthy BMI cut-points for South Asian populations (myocardial infarction, stroke or mortality)

No evidence was found relevant to healthy BMI cut-points for myocardial infarction, stroke or mortality in South Asian populations.

Evidence statement Q2.8: Healthy WC cut-points for South Asian populations (myocardial infarction, stroke or mortality)

No evidence was found relevant to WC as a predictor of myocardial infarction, stroke or mortality in South Asian populations.

Middle Eastern populations

Evidence statement Q2.9: Healthy BMI cut-points for Middle Eastern populations (Type 2 Diabetes)

Q2.9.a: UK and Western Countries

No evidence was found relevant to healthy BMI cut-points for diabetes in Middle Eastern populations in Western settings.

Q2.9.b: Other Countries

Moderate evidence from two cohort studies, one in men and one in women, (Hadaegh, 2006 [+/+])[5] and (Hadaegh, 2009 [+/+])[6] conducted in Iran suggest that an appropriate upper bound for a healthy BMI range with regards to diabetes in women may be as high as 30.5 kg/m^2; no lower boundary was identified. No healthy range was identified for males.

These studies had moderate applicability to the UK.

Evidence statement Q2.10: Healthy WC cut-points for Middle Eastern populations (Type 2 Diabetes)

Q2.10.a: UK and Western Countries

No evidence was found relevant to healthy WC cut-points for diabetes in Middle Eastern populations in the UK or other Western settings.

Q2.10.b: Other Countries

Moderate evidence from two studies, one in men and one in women, (Hadaegh, 2006 [+/+])[5] and (Hadaegh, 2009 [+/+])[6] conducted in Iran identified nohealthy WC cut-point for men. For women there was a significant increase in risk of diabetes above 87cm, suggesting that 86.9 cm may represent an appropriate healthy WC cut-off in Middle Eastern female populations.

These studies had moderate applicability to the UK.

No evidence – Middle Eastern populations

Evidence statement Q2.11: Healthy BMI cut-points for Middle Eastern populations (myocardial infarction, stroke and mortality)

No evidence was found relevant to healthy BMI cut-points for myocardial infarction, stroke and mortality in Middle Eastern populations.

Evidence statement Q2.12: Healthy WC cut-points for Middle Eastern populations (myocardial infarction, stroke and mortality)
No evidence was found relevant to healthy WC cut-points for myocardial infarction, stroke and mortality in Middle Eastern populations.

Chinese populations

Evidence statement Q2.13: Healthy BMI cut-points for Chinese populations (Type 2 Diabetes)
Q2.13.a: UK and Western Countries

No evidence was found relevant to healthy BMI cut-points for diabetes in Chinese populations in the UK or other Western settings.

Q2.13.b: Other Countries

There is moderate evidence from one cross sectional study conducted in Hong Kong (Thomas, 2004 [+/+])[10] that 22.1 kg/m^2 is an appropriate upper bound for a healthy BMI range in this population; no lower boundary was identified.

This study had moderate applicability to the UK.

Evidence statement Q2.14: Healthy WC cut-points for Chinese populations (Type 2 Diabetes)
Q2.14.a: UK and Western Countries

No evidence was found relevant to healthy WC cut-points diabetes in Chinese populations in the UK or other Western settings.

Q2.14.b: Other Countries

There is moderate evidence from one cross sectional study conducted in Hong Kong (Thomas, 2004 [+/+])[10] that 73.1 cm is an appropriate cut-point for a for a healthy population WC.

This study had moderate applicability to the UK.

No evidence – Chinese populations

Evidence statement Q2.15: Healthy BMI cut-points for Chinese populations (myocardial infarction, stroke or mortality)
No evidence was found relevant to healthy BMI cut-points for myocardial infarction, stroke or mortality in Chinese populations.

Evidence statement Q2.16: Healthy WC cut-points for Chinese populations (myocardial infarction, stroke or mortality)
No evidence was found relevant to healthy WC cut-points for myocardial infarction, stroke or mortality in Chinese populations.

Mixed ethnic populations

No evidence – Mixed ethnic populations

Evidence statement Q2.17: Healthy BMI cut-points for mixed ethnic populations (Type 2 Diabetes)

No evidence was found relevant to healthy BMI cut-points for diabetes in mixed ethnic populations.

Evidence statement Q2.18: Healthy BMI cut-points for mixed ethnic populations (myocardial infarction, stroke or mortality)

No evidence was found relevant to healthy BMI cut-points for myocardial infarction, stroke or mortality in mixed ethnicpopulations.

Evidence statement Q2.19: Healthy WC cut-points for mixed ethnic populations (Type 2 Diabetes)
No evidence was found relevant to healthy WC cut-points for diabetes in mixed ethnic populations.

Evidence statement Q2.20: Healthy WC cut-points for mixed ethnic populations (myocardial infarction, stroke or mortality)
No evidence was found relevant to healthy WC cut-points for myocardial infarction, stroke or mortality in mixed ethnic populations.

Question 3

Black populations

Evidence statement Q3.1: Optimal BMI cut-points for black populations (Type 2 Diabetes) to indicate need for preventative action

Q3.1.a: UK or Western Countries

Moderate evidence was found from one review (Qiao, 2010 [+/+])[11] and one cross-sectional study (Diaz 2007 [+/+])[12] indicating that the optimal BMI cut-point for the identification of prevalent diabetes in black populations is approximately 28 kg/m^2 for males and 28 to 30 kg/m^2 for females. Optimal values in English white populations were 28.2 kg/m^2 for males and 26.7 kg/m^2 for females.

These studies have moderate applicability to the UK.

Q3.1.b: Other Countries

Moderate evidence was found from one cohort study (Sargeant, 2002 [+/-])[3] that the optimal BMI cut-point for the prediction of incident diabetes amongst black populations in non-Western settings is 24.8 kg/m^2 for males and 29.3 kg/m^2 for females.

This study has weak applicability to the UK.

Evidence statement Q3.2: Optimal WC cut-points for black populations (Type 2 Diabetes) to indicate need for preventative action

Q3.2.a: UK or Western Countries

Moderate evidence was found from one review (Qiao, 2010 [+/+])[11] and one cross-sectional study (Diaz 2007 [+/+])[12] indicating that the optimal WC cut-point for the identification of prevalent diabetes in black populations ranges from 99 to 100.2 cm for males and 88.0 to 101 cm for females. This was compared to optimal values in English white populations of 103.4 cm for males and 91.4 cm for females.

These studies had moderate applicability to the UK.

Q3.2.b: Other Countries

Moderate evidence was found from one cohort study (Sargeant, 2002 [+/-]) that the optimal WC cut-point for the prediction of incident diabetes amongst black populations in non-Western settings is 88 cm for males and 84.5 cm for females.

This study has weak applicability to the UK.

No evidence – Black populations

Evidence statement Q3.3: Optimal BMI cut-points for black populations (myocardial infarction, stroke, mortality) to indicate need for preventative action

No evidence was found relevant to optimal BMI cut-points for myocardial infarction, stroke or mortality in black populations.

Evidence statement Q3.4: Optimal WC cut-points for black populations (myocardial infarction, stroke, mortality) to indicate need for preventative action

No evidence was found relevant to optimal WC cut-points for myocardial infarction, stroke or mortality in black populations.

South Asian populations

Evidence statement Q3.5: Optimal BMI cut-points for South Asian populations (Type 2 Diabetes) to indicate need for preventative action

Q3.5.a: UK or Western Countries

Moderate evidence was found from one cross-sectional study (Diaz 2007 [+/+])[12] indicating that the optimal BMI cut-point for the identification of diabetes in South Asian populations ranges from 24.2 to 26.5 kg/m^2 for males and 25.0 to 30.0 kg/m^2 for females. Optimal values in white English populations were 28.2 kg/m^2 and 26.7 kg/m^2 for females.

This study has moderate applicability to the UK.

Q3.5.b: Other Countries

Moderate evidence from one review (Nyamdorj, 2010 [+/+])[13] and two cross-sectional studies (Mohan, 2007 [+/-])[14] and (Jafar, 2006 [+/-])[15] indicates that the optimal BMI cut-points for the identification of diabetes in South Asian populations is approximately 22 to 23 kg/m^2 for males and 21 to 23 kg/m^2 for females, and that a BMI as low as 21 kg/m^2 may be appropriate for health promotion messages

These studies had weak to moderate applicability to the UK.

Evidence statement Q3.6: Optimal WC cut-points for South Asian populations (Type 2 Diabetes) to indicate need for preventative action

Q3.6.a: UK or Western Countries

Moderate evidence was found from one review (Qiao, 2010 [+/+])[11] and one cross-sectional study (Diaz 2007 [+/+])[12] indicating that the optimal WC cut-point for the identification of diabetes in South Asian populations ranges from 92.5 to 97.2 cm for males and 87.5 to 101.3 cm for females.

This study had moderate applicability to the UK

Q3.6.b: Other Countries

Moderate evidence from one review (Nyamdorj, 2010 [+/+])[13] and one cross-sectional study (Mohan, 2007 [+/-])[14] indicates that the optimal WC cut-points for the identification of diabetes in South Asian populations ranges from 85 to 87 cm for males and 82 to 83 cm for females.

These studies had weak to moderate applicability to the UK.

No evidence – South Asian populations

Evidence statement Q3.7: Optimal BMI cut-points for South Asian populations (myocardial infarction, stroke or mortality) to indicate need for preventative action

No evidence was found relevant to optimal BMI cut-points for myocardial infarction, stroke or mortality in South Asian populations.

Evidence statement Q3.8: Optimal WC cut-points for South Asian populations (myocardial infarction, stroke or mortality) to indicate need for preventative action

No evidence was found relevant to optimal WC cut-points for myocardial infarction, stroke or mortality in South Asian populations.

Middle Eastern populations

Evidence statement Q3.9: Optimal BMI cut-points for Middle Eastern populations (Type 2 Diabetes) to indicate need for preventative action

Q3.9.a: UK or Western Countries

No evidence was found reporting optimal BMI cut-points for the detection or prediction of diabetes among Middle Eastern populations in the UK or other Western Countries.

Q3.9.b: Other Countries

Moderate to strong evidence from one cohort study (Mansour, 2007 [++/+])[4] and three cross-sectional studies (Mirmiran, 2004 [++/+]),[16] (Mansour, 2007b [+/+])[17] and (Sarrafzadegan, 2010 [+/-])[18] indicates that the optimal cut-off value for the identification of prevalent diabetes among Middle Eastern populations living in non-Western countries ranges from 21.2 to 27 kg/m^2 for males and 23.1 to 29 kg/m^2 for females.

These studies have weak to moderate applicability to the UK.

Evidence statement Q3.10: Optimal WC cut-points for Middle Eastern populations (Type 2 Diabetes) to indicate need for preventative action

Q3.10.a: UK or Western Countries

No evidence was found reporting optimal WC cut-points for the identification of prevalent diabetes among Middle Eastern populations in the UK or other Western Countries.

Q3.10.b: Other Countries

Moderate to strong evidence from one cohort study (Mansour, 2007 [++/+])[4] and three cross-sectional studies (Mirmiran, 2004 [++/+]),[16] (Mansour, 2007b [+/+])[17] and (Sarrafzadegan, 2010 [+/-])[18] indicates that the optimal cut-off value for the identification of prevalent diabetes among Middle Eastern populations living in non-Western countries ranges from 80.7 to 92 cm for males and 84.7 to 95 cm for females.

These studies had weak to moderate applicability to the UK.

No evidence – Middle Eastern populations

Evidence statement Q3.11: Optimal BMI cut-points for Middle Eastern populations (myocardial infarction, stroke or mortality) to indicate need for preventative action

No evidence was found relevant to optimal BMI cut-points for myocardial infarction, stroke or mortality in Middle Eastern populations.

Evidence statement Q3.12: Optimal WC cut-points for Middle Eastern populations (myocardial infarction, stroke or mortality) to indicate need for preventative action

No evidence was found relevant to optimal WC cut-points for myocardial infarction, stroke or mortality in Middle Eastern populations.

Chinese populations

Evidence statement Q3.13: Optimal BMI cut-points for Chinese populations (Type 2 Diabetes) to indicate need for preventative action

Q3.13.a: UK or Western Countries

Moderate evidence was found from one cross-sectional study (Diaz 2007 [+/+])[12] indicating that the optimal BMI cut-point for the identification of prevalent diabetes in Chinese populations is 24.6 kg/m^2 for males and 24.1 kg/m^2 for females; this is lower than optimal values in white populations.

This study had moderate applicability to the UK.

Q3.13.b: Other Countries

Moderate evidence was found from two reviews (Nyamdorj, 2010 [+/+])[13] and (Qiao, 2010 [+/+])[11] and one cross-sectional study (Ko, 1999 [+/-])[19] and indicating that the optimal BMI cut-point for the identification of prevalent or incident diabetes in Chinese populations ranges from 23.3 to 25.8 kg/m^2 for males and 18.4 to 25.4 kg/m^2 for females.

These studies had weak to moderate applicability to the UK.

Evidence statement Q3.14: Optimal BMI cut-points for Chinese populations (myocardial infarction, stroke or mortality) to indicate need for preventative action

No evidence was found relevant to optimal BMI cut-points for myocardial infarction, mortality in Chinese populations.

Q3.14.a: UK or Western Countries

No evidence was found reporting optimal BMI cut-points for the identification of previous stroke among Chinese populations living in the UK.

Q3.14.b: Other Countries

Weak evidence was found from one cross-sectional study (Ho, 2003 [-/-])[20] indicating that BMI does not accurately indentify previous stroke in Chinese populations living in Hong Kong.

This study had weak applicability to the UK.

Evidence statement Q3.15: Optimal WC cut-points for Chinese populations (Type 2 Diabetes) to indicate need for preventative action

Q3.15.a: UK or Western Countries

Moderate evidence was found from one cross-sectional study (Diaz 2007 [+/+])[12] indicating that the optimal WC cut-point for the identification of prevalent diabetes in Chinese populations in the UK or other western countries is 95.1 cm for males and 83.7 cm for females. These cut-points were lower than those identified for both white males and females.

These studies had moderate applicability to the UK

Q3.15.b: Other Countries

Moderate evidence was found from two reviews (Nyamdorj, 2010 [+/+])[13] and (Qiao, 2010 [+/+])[11] one cross-sectional study (Ko, 1999 [+/-])[19] indicating that the optimal WC cut-point for the identification of prevalent diabetes in Chinese populations in Hong Kong or other non-Western settings ranges from 84 to 88.2 cm for males and 78.4 to 85.3 cm for females.

These studies had weak to moderate applicability to the UK.

Evidence statement Q3.16: Optimal WC cut-points for Chinese populations (myocardial infarction, stroke or mortality) to indicate need for preventative action

No evidence was found relevant to optimal WC cut-points for myocardial infarction or mortality in Chinese populations.

Q3.16.a: UK or Western Countries

No evidence was found reporting optimal WC cut-points for the identification of stroke among Hong Kong Chinese populations living in the UK.

Q3.16.b: Other Countries

Weak evidence was found from one cross-sectional study (Ho, 2003 [-/-])[20] indicating that WC does not accurately indentify previous stroke in Chinese populations living in Hong Kong.

This study had weak applicability to the UK.

Mixed ethnic populations

Evidence statement Q3.17: Optimal BMI cut-points for mixed ethnic populations (Type 2 Diabetes) to indicate need for preventative action

Q3.17.a: UK or Western Countries

No evidence was found reporting optimal BMI cut-points for the identification of prevalent diabetes among mixed populations in solely the UK or other Western Countries.

Moderate evidence was found from two reviews (Huxley, 2008 [+/+])[21] and (Qiao, 2010 [+/+])[11] indicating that the optimal BMI cut-point for the identification of prevalent diabetes in mixed ethnic populations is approximately 24 kg/m^2 for males and 23 to 25 kg/m^2 for females.

These studies had weak to moderate applicability to the UK.

Evidence statement Q3.18: Optimal WC cut-points for mixed ethnic populations (Type 2 Diabetes) to indicate need for preventative action

Q3.18.a: UK or Western Countries

No evidence was found reporting optimal WC cut-points for the identification of prevalent diabetes among mixed ethnic populations in solely the UK or other Western countries.

Q3.18.b: Other Countries

Moderate evidence was found from two reviews (Huxley, 2008 [+/+])[21] and (Qiao, 2010 [+/+])[11] indicating that the optimal WC cut-point for the identification of prevalent diabetes in mixed ethnic populations is 85 cm for males and approximately 80 cm for females.

These studies had moderate applicability to the UK.

No evidence – Mixed ethnic populations

Evidence statement Q3.19: Optimal BMI cut-points for mixed ethnic populations (myocardial infarction, stroke or mortality) to indicate need for preventative action

No evidence was found relevant to optimal BMI cut-points for myocardial infarction, stroke or mortality in mixed ethnic populations.

Evidence statement Q3.20: Optimal WC cut-points for mixed ethnic populations (myocardial infarction, stroke or mortality) to indicate need for preventative action

No evidence was found relevant to optimal WC cut-points for myocardial infarction, stroke or mortality in mixed ethnic populations.

Question 4

Black populations

Evidence statement Q4.1: BMI cut-points indicating “risk equivalence” for black populations (Type 2 Diabetes)

Limited evidence suggests that black populations with a BMI of 26 kg/m^2 were found to have the same diabetes risk as white populations with a BMI of 30kg/m^2, and 21 to 23 kg/m^2 appears to be risk equivalent to 25 kg/m^2 in a white population.

Q4.1.a: UK or Western Countries

Moderate evidence was found from two cohorts in Canada and the US and two cross-sectional studies in the US (Chiu, 2011 [+/+]),[22] (Stevens, 2008 [+/+])[23], (Stommel, 2010 [+/+])[24] and (Taylor, 2010 [++/+])[8] that for BMI around 30 kg/m^2 in white populations the equivalent incident diabetes risk in black populations was found at BMI values 4 units lower (26 kg/m^2). For a BMI around 25 kg/m^2 in white populations the equivalent incident diabetes risk in black populations was found at BMI values 2 to 4 units lower 21 to 23 kg/m^2).

These studies had moderate applicability to the UK.

No evidence – Black populations

Evidence statement Q4.2: BMI cut-points indicating "risk equivalence" for black populations (myocardial infarction, stroke or mortality)

No evidence was found relevant to risk equivalent BMI cut-points for myocardial infarction, stroke or mortality in black populations.

Evidence statement Q4.3: WC cut-points indicating "risk equivalence" for black populations (Type 2 Diabetes)

No evidence was found relevant to risk equivalent WC cut-points for diabetes in black populations.

Evidence statement Q4.4: WC cut-points indicating "risk equivalence" for black populations (myocardial infarction, stroke or mortality)

No evidence was found relevant to risk equivalent WC cut-points for myocardial infarction, stroke or mortality in black populations.

South Asian populations

Evidence statement Q4.5: BMI cut-points indicating "risk equivalence" for South Asian populations (Type 2 Diabetes)

Q4.5.a: UK or Western Countries

Moderate evidence was found from one cohort in Canada (Chiu, 2011 [+/+])[22] that for BMI around 30 kg/m^2 in white populations the equivalent incident diabetes risk in South Asian populations was found at BMI values 6 units lower. No equivalent value to a BMI of 25 kg/m^2 was reported.

This study had moderate applicability to the UK.

Q4.5.b: Other Countries

Moderate graphical evidence was found from one review (Nyamdorj, 2010b [+/++])[25] related to diabetes risk across BMI values, indicating a risk equivalence at 19 to 20 kg/m^2 among South Asian men and 30 kg/m^2 among European men. No risk equivalence points were identified for women at this BMI cutoff, and no values were identified for either men or women equivalent to the risk seen among Europeans at 25 kg/m^2.

This study had strong applicability to the UK.

Evidence statement Q4.6: WC cut-points indicating “risk equivalence” for South Asian populations (Type 2 Diabetes)

Moderate graphical evidence was found from one review (Nyamdorj, 2010b [+/++])[25] that at a WC of 73 cm, Indian men experience the same diabetes risk as European men exhibit at 102 cm. No risk equivalent values were identified for the Europen WC cut-off of 94 cm among men, 88 cm among women or 80 cm among women.

This study had strong applicability to the UK.

No evidence – South Asian populations

Evidence statement Q4.7: BMI cut-points indicating “risk equivalence” for South Asian populations (myocardial infarction, stroke or mortality)

No evidence was found relevant to risk equivalent BMI cut-points for myocardial infarction, stroke or mortality in South Asian populations.

Evidence statement Q4.8: WC cut-points indicating “risk equivalence” for South Asian populations (myocardial infarction, stroke or mortality)

No evidence was found relevant to risk equivalent WC cut-points for myocardial infarction, stroke or mortality in South Asian populations.

Middle Eastern populations

No evidence – Middle Eastern populations

Evidence statement Q4.9: BMI cut-points indicating "risk equivalence" for Middle Eastern populations (Type 2 Diabetes)

No evidence was found relevant to risk equivalent BMI cut-points for diabetes Middle Eastern populations.

Evidence statement Q4.10: BMI cut-points indicating "risk equivalence" for Middle Eastern populations (myocardial infarction, stroke or mortality)

No evidence was found relevant to risk equivalent BMI cut-points for myocardial infarction, stroke or mortality in Middle Eastern populations.

Evidence statement Q4.11: WC cut-points indicating "risk equivalence" Middle Eastern populations (Type 2 Diabetes)

No evidence was found relevant to risk equivalent WC cut-points for diabetes in Middle Eastern populations.

Evidence statement Q4.12: WC cut-points indicating "risk equivalence" for Middle Eastern populations (myocardial infarction, stroke or mortality)

No evidence was found relevant to risk equivalent WC cut-points for myocardial infarction, stroke or mortality in Middle Eastern populations.

Chinese populations

Evidence statement Q4.13: BMI cut-points indicating "risk equivalence" for Chinese populations (Type 2 Diabetes)

Q4.13.a: UK or Western Countries

Moderate evidence was found from two cohorts (Chiu, 2011 [+/+]),[22] (Stevens, 2008 [+/+])[23] that for a BMI around 30 kg/m^2 in white populations the equivalent incident diabetes risk in Chinese populations was found at BMI values 2.5 to 5 units lower. In one (Stevens, 2008 [+/+])[23] for a BMI around 25 kg/m^2 in white populations the equivalent incident diabetes risk in Chinese populations was found at BMI values 2 units lower.

These studies have moderate applicability to the UK.

Q4.13.b: Other Countries

One review of studies (Nyamdorj, 2010b [+/++])[25] provides moderate evidence that for a BMI around 30 kg/m^2 in white populations the equivalent incident diabetes risk in Chinese men was found at BMI values 5 kg/m^2 lower for Chinese men and 8 kg/m^2 lower for Chinese women.

This review had moderate applicability to the UK.

Evidence statement Q4.14: WC cut-points indicating "risk equivalence" for Chinese populations (Type 2 Diabetes)

Q4.14.a: UK or Western Countries

No evidence was found relevant to risk equivalent WC cut-points for diabetes in Chinese populations in the UK or other Western populations.

Q4.14.b: Other countries

Moderate graphical evidence was found from one review (Nyamdorj, 2010b [+/++])[25] that a diabetes risk equivalent WC for Chinese men is 82 cm compared to 102 cm in European men, and 67 to 70 cm among Chinese men was found to be risk equivalent to 94 cm among European men. An equivalent diabetes risk is seen among Chinese women at 70 to 73 cm, compared to 88 cm in European women.

This study has moderate applicability to the UK.

No evidence – Chinese populations

Evidence statement Q4.15: BMI cut-points indicating "risk equivalence" for Chinese populations (myocardial infarction, stroke or mortality)
No evidence was found relevant to risk equivalent BMI cut-points for myocardial infarction, stroke or mortality in Chinese populations.

Evidence statement Q4.16: WC cut-points indicating "risk equivalence" for Chinese populations (myocardial infarction, stroke or mortality)
No evidence was found relevant to risk equivalent WC cut-points for myocardial infarction, stroke or mortality in Chinese populations.

Mixed ethnic populations

Evidence statement Q4.17: Optimal BMI cut-points for mixed ethnic populations (Type 2 Diabetes)
No evidence was found relevant to risk equivalent WC cut-points for diabetes in mixed ethnic populations.

Evidence statement Q4.18: Optimal WC cut-points for mixed ethnic populations (Type 2 Diabetes)
No evidence was found relevant to risk equivalent BMI cut-points for myocardial infarction, stroke or mortality in mixed ethnic populations.

Evidence statement Q4.19: BMI cut-points indicating "risk equivalence" for mixed ethnic populations (myocardial infarction, stroke or mortality)
No evidence was found relevant to risk equivalent BMI cut-points for myocardial infarction, stroke or mortality in mixed ethnic populations.

Evidence statement Q4.20: WC cut-points indicating "risk equivalence" for mixed ethnic populations (myocardial infarction, stroke or mortality)
No evidence was found relevant to risk equivalent WC cut-points for myocardial infarction, stroke or mortality in mixed ethnic populations.

1.4 Discussion

This report addresses an ongoing debate about the interpretation of recommended body-mass index (BMI) or waist circumference cut-off points for determining overweight and obesity in black, Asian and minority ethnic populations in the UK. It reports the evidence that could inform a decision of whether population-specific cut-off points for BMI and or WC are necessary.

Key Messages

Together the research identified that could answer these four questions has methodological limitations and care is needed in interpreting it. The direct applicability to UK populations of much of the data identified may be limited. The cut-off point for observed risk of diabetes varies from 22 kg/m^2 to 25 kg/m^2 in different black, Asian and minority ethnic populations and for high risk it varies from 26 kg/m^2 to 31 kg/m^2. The data is consistent with a 2 to 3 unit reduction in cut-point of BMI for South Asian and Chinese groups, and a 10 cm or more reduction in WC cut-point for South Asian males and Chinese males and females in the UK. The evidence surrounding Middle Eastern populations in the UK indicates that a reduction in BMI and WC may be appropriate, while studies in black populations suggest that an increase in BMI and WC cutoffs may be indicated. However, the evidence in these populations is inconsistent with regards to the the direction and magnitude of risk difference compared to white populations.

Question 1

Overall, lower BMI and WC are associated with a lower risk for several long term conditions including diabetes and cardiovascular disease.

The accuracy of the anthropometric indices, BMI and WC, in predicting future risk of disease can be assessed by prospective studies that use multivariate analysis or adjusted univariate analysis. Other researchers have developed and tested prediction models that take into account all the risk factors for diabetes, and the prevention of type 2 diabetes and cardiovascular disease have been reviewed in NICE guideance.[26] Some models for predicting diabetes risk already exist and are validated in UK populations.[27]

Cardiovascular scores that include ethnicity as a variable can achieve an AUC of 0.817. Those without ethnicity as a variable and using a modified

Framingham equation can also achieve an AUC of 0.80.[26] Refitting of this algorithm for a wider age range has improved AUC for women to 0.853 and for men 0.830.[28] This indicates that existing validated models for predicting diabetes risk have similar abilities to correctly classify diabetes cases, although modified Framingham equations perform slightly better than models that account for ethnicity. These models would, in theory, provide a benchmark area under the curve (AUC) against which the performance of single anthropometric measures could be compared.

Against this benchmark the range of the AUCs described in this report are moderate. The maximum discriminative power (AUC) of BMI and WC in the studies included in this review was 0.74 for BMI and 0.78 for WC, both amongst black populations. The AUC for BMI in South Asian, Middle Eastern, Chinese and mixed ethnicity populations ranged from 0.61 to 0.69. The AUC for waist circumference in the populations ranged from 0.62 to 0.71. This indicates that existing prediction models, which include ethnicity as a variable, perform better as predictors of Type 2 diabetes than either BMI or WC individually.

Limitations to this interpretation include the fact that not all studies were directly applicable to the UK population. Furthermore, prevalence of disease is an important consideration when assessing the positive predictive value of tests or prediction models and the AUC can vary depending on how well the cut-points are calibrated to the specific population studied.

Question 2

A healthy BMI range or WC cut-point can be identified by assessing the association between BMI or WC and diabetes, myocardial infarction, stroke or mortality. Above a certain point on this continuous scale, studies have reported the boundary level above which any outcome increase becomes statistically significant.

Using this approach, no appropriate BMI lower boundaries for a healthy range amongst black, Asian and minority ethnic populations in the UK were identified. Individual studies identified upper limits to a healthy population BMI range of approximately 25 kg/m^2 in white populations, 30 kg/m^2 in black populations, 23 kg/m^2 in South Asian populations, 30.5 kg/m^2 in Middle Eastern populations and 22 kg/m^2 in Chinese populations. All of these studies were conducted in non-UK settings, and no upper limit could be identified for black, Asian and ethnic minority populations resident in the UK.

Waist circumference in a single Middle Eastern study had a threshold of about 87 cm for women that could indicate the boundary level above which any diabetes increase becomes statistically significant. Among South Asian populations, a waist circumference of approximately 85 cm for males and 80 cm for females was identified by a single study as an appropriate boundary above which risk of diabetes increases significantly. Another study identified 73 cm as the appropriate WC boundary in Chinese populations. No WC boundaries were found for black populations.

This approach is similar to that adopted by the WHO in its consideration of evidence underlying the original consensus statement on BMI cut-points for defining obesity. However the studies identified in this review do not provide strong evidence for ethnic specific variations in defining the ‘healthy range’ based on this approach.

Question 3

The cut-points along the scale of anthropometric indices, BMI or WC, that indicate the need for preventative action can be inferred in several ways using ROC analysis. First, the cut-point that results in the highest sensitivity, and therefore fewest people (false negatives), who fall below the threshold of overweight and who go on to develop disease. This method is likely the most appropriate for public health programmes. Only one study presented sensitivity data over the range of BMI values, however. Optimal cut-points were defined in most studies as the point on a ROC curve that relates to maximum sensitivity and specificity (as a trade-off in both). This is an idealised value that results in fewest false negatives and false positives. This threshold is important when considering the point at which preventive interventions or programmes for prevention could be considered. It represents the point at which the fewest people are provided with preventive interventions or treatments unnecessarily and the point at which the fewest people are excluded from an intervention that might benefit them. Selecting such a point is however a trade-off and the utility of any cut-off points identified also depends on the effectiveness of any interventions offered at these points. Assuming this BMI point is 25 kg/m^2, and WC points are 94 cm for men and 80 cm for women in European/white populations, we compared these points as reported in the included studies. Across studies the optimal cut-point is a BMI between 25 kg/m^2 and 30 kg/m^2, and a WC of approximately 100 cm for males and between 88 and 101 cm for females for diabetes outcomes in black populations. These values were lower for South Asian groups (about a midpoint BMI of 24.5 kg/m^2 and WC of 92 cm for men and women). Studies conducted in Middle Eastern countries showed an optimum cut-point close to BMI 25 kg/m^2 and 88 cm for WC. In Chinese populations the optimal cut-points are slightly lower for both BMI (about 23 to 24 kg/m^2) and WC (about 88 cm for males and 83 cm for females). For comparison, cut-points in European or white populations identified in these studies were approximately 27 kg/m^2 for BMI, 100 cm among males and 90 cm among females for waist circumference.

These do not suggest a clear rationale for changing BMI or WC cut-points for an overweight category suitable for targeted prevention in all ethnic groups. There is moderate evidence BMI and WC cut-points should be lower for South Asian and Chinese groups, but the evidence surrounding black and Middle Eastern populations cut-points is less consistent.

Question 4

This question seeks to compare the average risks for individuals and populations from different ethnic groups with those expected for European populations at the existing 25 kg/m^2 and 30 kg/m^2 cut-points. The evidence is best inferred from graphs of BMI against incident or prevalent disease by drawing a horizontal line that intersects all plots and is drawn at the level of risk equivalent to a BMI or WC threshold in white populations. Studies are included if they have reported risk in this way and include the relevant ethnic groups compared to white populations.

Incidence and prevalence of diabetes is higher at all BMI and WC cut-points for all minority groups in comparison to white populations. The equivalent risk at a BMI of 30 kg/m^2 in white population occurs in black or south Asian groups up to 6 units lower (BMI). In south Asian groups the equivalent risk at a WC of 102 cm in white male populations occurs at up to 29 cm lower. These studies variably report the additional risk factors that were adjusted for in these analyses. Caution is advised in interpreting the unadjusted incidence and unadjusted prevalence rates which have come from cross-sectional studies. One large US study (Stommel, 2010 [+/+])[24] adjusted for age, sex, education, poverty, marital status, insurance, residency, health behaviours and foreign birth. In these fully adjusted analyses in US populations, similar equivalent BMI or WC equivalents occurred across black, Hispanic, East Asian and white groups (See Figure 10). This could imply that much of the separation of the ethnic specific rates of diabetes, the gap between these curves, is due to confounding by diabetes risk factors other than obesity, and not fully accounted for.

Summary

These findings do not support the use of a universal lower BMI cut-off point in all black, Asian and minority ethnic groups for defining overweight or obesity and the preventive interventions that might be offered to people passing these cut-points. With respect to ethnicity specific cut-off points, there was substantial evidence of population-dependent variations in association of disease risk with measures of obesity. South and East Asian populations of greatest interest in this respect, as risks of certain diseases (e.g. diabetes) are notably higher in these populations than would be expected from their mean BMI levels. Understanding the basis for this increased risk of diabetes among these populations is important for identifying the potential environmental causes and the heterogeneity among these populations.

However, populations with BMI greater than or equal to 25 kg/m^2 are rapidly increasing around the world and have substantial risks of disease. To pre-empt the rapid increases in obesity and related health problems that are occurring in South Asian populations a BMI of 23 kg/m^2 and an associated lower waist circumference cut-off, could be justified as suitable action points for public health obesity prevention and control interventions. The WHO consultation identified several potential public health action points (23·0, 27·5, 32·5, and 37·5 kg/m^2) along the continuum of BMI, and proposed methods by which countries could make decisions about the definitions of increased risk for their population. Based on this report a threshold of 23.0 kg/m^2 for South Asian and Chinese groups in the UK is not inconsistent with this approach. The evidence for Middle Eastern and black populations in the UK is less consistent, with evidence for a 2 to 3 unit reduction in BMI as well as evidence supporting no change in BMI and WC cut-points among this population. Among black populations, the direction of the evidence is inconsistent, with some studies indicating tha an optimal BMI and WC cut-point may be higher than those seen in white populations, while other studies indicate that black populations have an equivalent diabetes risk at 2 to 4 BMI units lower than European or white groups.

2 Introduction

2.1 Background

The National Institute for Health and Clinical Excellence (NICE) has been asked by the Department of Health (DH) to assess the body mass index (BMI) and waist circumference thresholds for intervening to prevent ill health among adults (aged 18 years and over) from black, Asian and other minority ethnic groups in the UK.

Two anthropometric indices, body mass index (BMI) and waist circumference (WC) are the primary measures of body composition currently used to assess overall obesity and abdominal obesity. In developed countries they are used as proxy measures of health risk for individuals and populations, particularly for risk of non-communicable diseases such as heart disease, stroke and cancer. According to the World Health Organisation (WHO), in developing nations they have historically been used to assess undernutrition, though increasingly both undernutrition and non-communicable diseases are being recognised together in populations in these countries.[29]

Obesity is defined by the WHO (2000) as a condition of abnormal or excessive fat accumulation in adipose tissue to the extent that health is impaired.[30]

2.2 Population groups

The latest population estimates by ethnic group for England and Wales indicate that the majority White British group has stayed constant in size between 2001 and 2009 while the population belonging to other groups has risen, see Table 1.

According to mid-2009 ONS population estimates, 6.62 million people in England and Wales now identify as belonging to a black, Asian or other minority ethnic group, representing 12.1% of the total population.[31]

The concept of 'ethnicity' or 'ethnic group' is difficult to define.[32] It is a multidimensional concept with dimensions of, colour, national identity, citizenship, religion, language, country of birth and culture. When a person identifies with a particular ethnic group, it may imply shared origins, social background, culture, or traditions which are distinctive and maintained between generations. However, in a world of migration and mixing, the concept of ethnicity is dynamic. It is virtually impossible to create single, mutually exclusive categories of self identified ethnicity. Amongst the 16 ethnic groups listed in the Census for the UK, it is those who identify as black Asian, Chinese and minority groups listed in Table 1 who are the focus of this review.

Nearly half (48%) of the total black and minority ethnic population live in the London region, where they comprise 29% of all residents.[33]

Table 1: Population Growth by Ethnic Group: England and Wales: 2002 – 2009

Ethnic group	Mid- 2009 population (thousands)	Average annual percentage growth (%)	Proportion of total population (%)
All groups	54,809.1	0.6	100%
White : British	45,682.1	0.0	83.3%
White: Irish	574.2	-1.5	1.0%
White: other white	1932.6	4.3	3.5%
Mixed: White and Black Caribbean	310.6	3.3	0.6%
Mixed: White and Black African	131.8	6.3	0.2%
Mixed: White and Asian	301.6	5.8	0.6%
Mixed: Other Mixed	242.6	5.5	0.4%
Asian: Indian	1434.2	3.9	2.6%
Asian: Pakistani	1007.4	4.1	1.8%
Asian: Bangladeshi	392.2	4.0	0.7%
Other Asian	385.7	5.7	0.7%
Black Caribbean	615.2	0.9	1.1%
Black African	798.8	6.2	1.5%
Other Black	126.1	3.2	0.2%
Chinese	451.5	8.6	0.8%
Other	422.6	8.0	0.8%
Non-'White British'	9127.1	4.1	16.7%
Black, Asian and other minority ethnic group	6620.3		12.1%

Source: Office for National Statistics. Population Estimates by Ethnic Group 2002 – 2009, May 2011.[31]

2.3 The importance of and prevalence of obesity

2.3.1 Body Mass Index (BMI)

The most common method of measuring obesity is by calculating an individual's Body Mass Index (BMI). This is calculated by dividing a person's weight measurement (in kilograms) by the square of their height (in metres).

In adults, a BMI of 25 to 29.9 kg/m^2 is categorised as overweight and a BMI of 30 kg/m^2 or above as obese.

BMI is currently the most commonly used method for measuring the prevalence of obesity at the population level. No specialised equipment is needed and therefore it is easy to measure accurately and consistently across large populations. BMI is also widely used around the world, which enables comparisons between countries, regions and population sub-groups.

For most people, BMI correlates well with their level of body fat. However, certain factors such as fitness and ethnic origin are thought to alter the relationship between BMI and body fat. Other measurements of obesity distribution, such as waist circumference are often collected to confirm an individual person's weight status and provide a better measure of abdominal obesity.[34]

2.3.2 Waist circumference

Waist circumference is also used as a measure of obesity. A 'raised' waist circumference is defined as above 102 cm for men and above 88 cm for women. These cut-off points correspond to the risk threshold for a range of chronic diseases and mortality among Europeans.[30] Several methods for measuring waist circumference have been reported, which may make comparing measures between studies and countries difficult. The most commonly used method identified in the current review assessed waist circumference midway between the costal margin and iliac crest. Alternative measures include at the umbilicus, or midway between the xyphoid process and umbilicus.

2.3.3 Obesity worldwide

Obesity is a public health problem that has become epidemic worldwide.[35] Overweight and obesity are accepted as major risk factors for type 2 diabetes, cardiovascular diseases (coronary heart disease and stroke) and various cancers. These can lead to further morbidity and mortality. A public health approach to developing population-based strategies for the prevention of excess weight gain is of great importance. However, public health intervention programmes have had limited success so far in tackling the rising prevalence of obesity.

According to the WHO, there will be about 2.3 billion overweight people aged 15 years and above, and over 700 million obese people worldwide in 2015.[29]

Overweight and obesity are the fifth leading risk factor for global deaths. The WHO reports that at least 2.8 million adults die each year globally as a result of being overweight or obese. In addition, 44% of the diabetes burden, 23% of the ischaemic heart disease burden and between 7% and 41% of certain cancer burdens are attributable to overweight and obesity.[29]

Although a few developed countries have experienced a drop in the prevalence rate of obesity in the past decade, the prevalence of obesity continues to rise in many parts of the world, especially in the Asia Pacific region.[36,37] For example, the Asia Pacific Cohort Studies Collaboration reports that the combined prevalence of overweight and obesity increased in China from 3.7% in 1982 to 19.0% in 2002.[38]

The prevalence of obesity worldwide is important to this review as many studies included have been conducted in countries other than the UK. The mean BMI reported in the "county of birth" of first generation migrants to the UK can be informative when assessing the applicability of these studies. A WHO report from the Global Health observatory (2012) estimates the prevalence of overweight and obesity in the WHO Regions. Rates were highest in the Americas (62% for overweight and 26% for obesity for both sexes) and lowest in the WHO Region for South East Asia (14% for overweight and 3% for obesity in both sexes).[39] In the WHO Region for Europe, the Eastern Mediterranean and the Americas over 50% of women were overweight.[39] For all three of these regions, roughly half of overweight women are obese (23% in Europe, 24% in the Eastern Mediterranean, 29% in the Americas).[39] In all WHO regions women were more likely to be obese than men. In the WHO regions for Africa, Eastern Mediterranean and South East Asia, women have roughly double the obesity prevalence of men.

2.3.4 Obesity in the UK

Obesity imposes a significant human burden of morbidity, mortality, social exclusion and discrimination. There is also a significant healthcare cost associated with treating obesity and its direct consequences. Social care costs are also higher for people who are obese. Higher levels of sickness and absence from work among people who are obese reduce productivity and impose costs on businesses. Premature mortality as a consequence of obesity reduces the national output relative to the level it would be in the absence of obesity.[40]

The National Obesity Observatory reports that the prevalence of obesity in England has more than doubled in the last 25 years and is amongst the highest amongst the 34 countries who are members of the Organisation for Economic Co-operation and Development (OECD).[34] The OECD is an international organisation of richer countries dedicated to global development. The latest Health Survey for England (HSE) data shows that in England in 2010:[41,42]

- 62.8% of adults (aged 16 or over) were overweight or obese
- 30.3% of children (aged 2-15) were overweight or obese
- 26.1% of all adults and 16% of all children were obese

Foresight's Tackling Obesities: Future Choices report, published in October 2007, predicted that if no action was taken, 60% of men, 50% of women and 25% of children in Britain would be obese by 2050.[43]

Obesity negatively impacts on health related quality of life (HRQL) and there is evidence that the negative impact of obesity is greater in people from lower socioeconomic status (SES) groups. Overweight and obese people in lower SES groups have lower HRQL than those of normal weight in the same SES group, and have lower HRQL than those in higher SES groups of the same weight.[44]

The estimated cost of people being overweight or obese is expected to grow to £49.9 billion by 2050.[43]

2.3.5 Obesity amongst black, Asian and other ethnic minority groups in the UK

The National Obesity Observatory report that apart from Health Survey for England (HSE) data from 2004, there is little nationally representative data on obesity prevalence in adults from minority ethnic groups in the UK.[32]

The Health Survey for England (HSE) 2004 contained a sample of individuals from minority ethnic groups and gives the most recent robust data on adult obesity prevalence by ethnic group. Findings suggest that compared to the general population, obesity (BMI more than 30 kg/m^2) prevalence is lower among men from Black African, Indian, Pakistani, and, most markedly, Bangladeshi and Chinese communities. Among women, obesity prevalence appears to be higher for those from Black African, Black Caribbean and Pakistani groups than for women in the general population and lower for women from the Chinese ethnic group. See Figures 1 and 2.

Figure 1: Body mass index and waist circumference by ethnic group, 2004, England. (men)

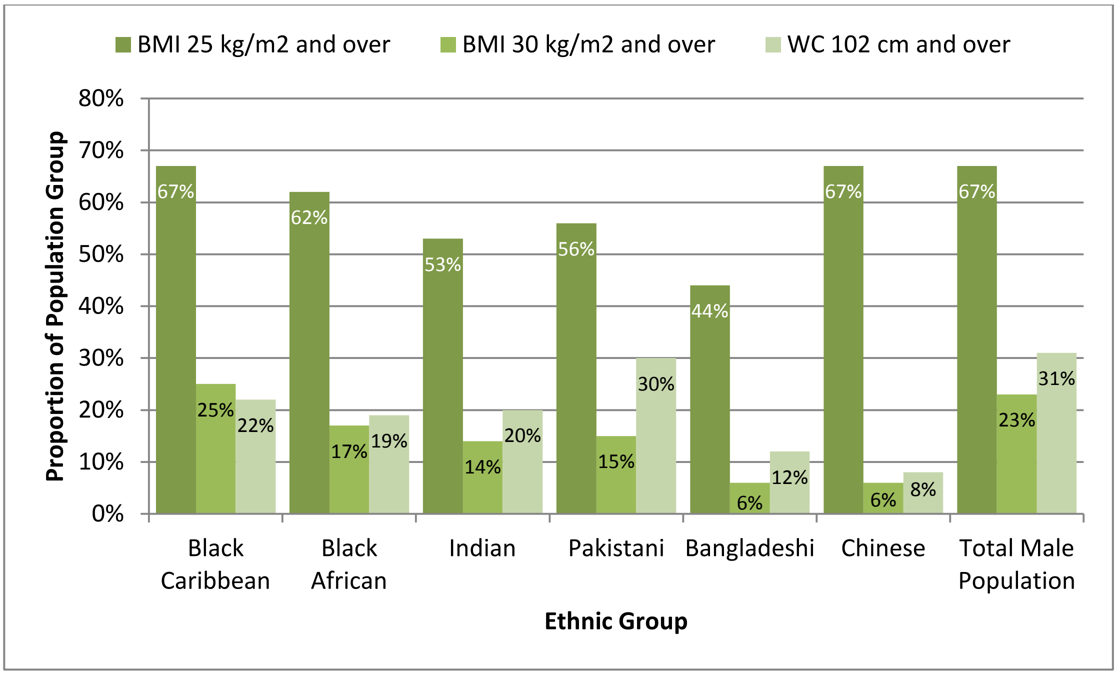
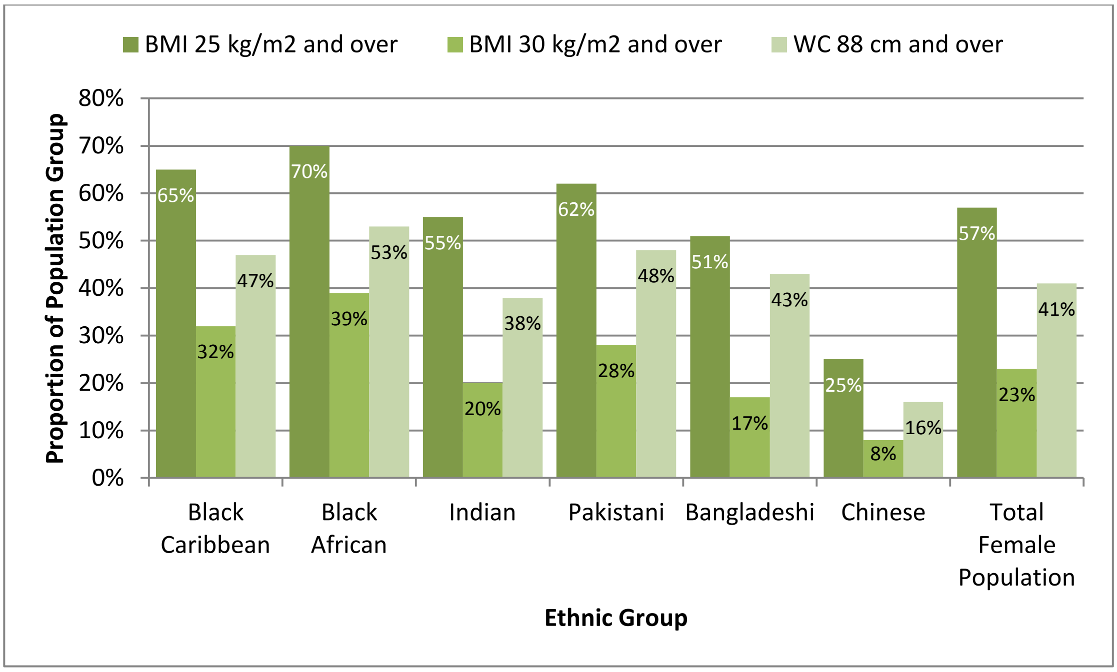


Figure 2: Body mass index and waist circumference by ethnic group, 2004, England (women)



Source: Adapted from Joint Health Surveys Unit (2005) Health Survey for England 2004. The Health of Minority Ethnic Groups. Department of Health: London.[45]

The Foresight report also modelled the trend in obesity amongst ethnic groups, see Table 2, noting that data sets for some ethnic groups in the 2004 Health Survey for England were relatively small.[43] Black Caribbean and Chinese groups appear to be becoming less obese, with trends suggesting a proportion of just 3% being obese by 2050. Bangladeshi men are also becoming less obese, but this is not the case with Bangladeshi women, although the increase is modest (6% increase). Indian men and women demonstrate smaller increases, while black African women and Pakistani men and women appear to share the trend of the white population.

Table 2: Predicted percentage of population who are obese (ie. BMI ≥ 30kg/m^2) at 2006 and 2050, by ethnic group

Ethnic group	Males (%)		Females (%)		Number of Health Survey for England records, 1993-2004 (% of records)
	2006	**2050**	**2006**	**2050**	
White	26	63	23	57	139,914 (94.2)
Black Caribbean	18	3	14	1	1,458 (0.98)
Black African	17	37	30	50	1,036 (0.70)
Indian	12	23	16	18	2,848 (1.92)
Pakistani	16	50	22	50	2,236 (1.51)
Bangladeshi	26	17	24	30	836 (0.56)
Chinese	3	1	3	1	182 (0.12)

Source: Foresight Tackling Obesities: Future Choices – Modelling Future Trends in Obesity and the Impact on Health 2nd Edition.[43]

2.4 Prevalance of type 2 diabetes

In the UK, type 2 diabetes is more prevalent among black Caribbean, Indian, Pakistani and Bangladeshi men aged 35–54 than the general population. With the exception of black African men, it is also more prevalent among those aged 55 and over from these groups. Among women, type 2 diabetes is more common among Indian, Pakistani and Bangladeshi groups (aged 35 years and over) and black Caribbean women (aged 55 years and over).[45] People from black, Asian and other minority ethnic groups also tend to progress from impaired glucose tolerance (IGT) to diabetes much more quickly than average (more than twice the rate of white populations).[46]

2.5 Obesity and diabetes

People of South Asian descent living in the UK are up to six times more likely to have type 2 diabetes, and develop the condition 10 years earlier than white populations in the UK. People of African and African-Caribbean descent are three times more likely to have type 2 diabetes than the white population, and the condition is also more common among Chinese and other non-white groups than among white European populations.[26]

The higher risk for South Asian people living in the UK is at least partly due to the fact that they may accumulate significantly more 'metabolically active' fat in the abdomen and around the waist than white European populations. This is true even for those with a BMI in the 'healthy' range – that is, 18.5 to 24.9 kg/m^2. 'Metabolically active' fat is closely associated with insulin resistance, pre-diabetes and type 2 diabetes.[26]

Minority ethnic groups are less likely to participate in at least moderate-intensity physical activity (for 30 minutes continuously a week) than the general population. For example Bangladeshi men and women have the lowest levels of participation in physical activity when standardised for age.[47] Black Caribbean men are the only subgroup of an ethnic minority population that are not less physically active than the general population in England.[47]

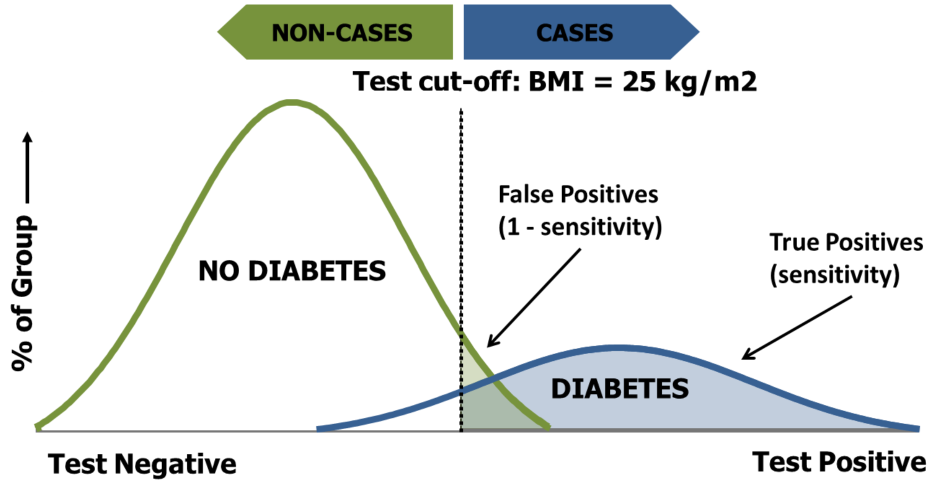
2.6 Measures of diagnostic accuracy and obesity

2.6.1 Rationale for selection of cut-off points

The most common approach to determining optimised cut-off points is based on the use of sensitivity and specificity as interpreted from receiver operating characteristic (ROC) curves.

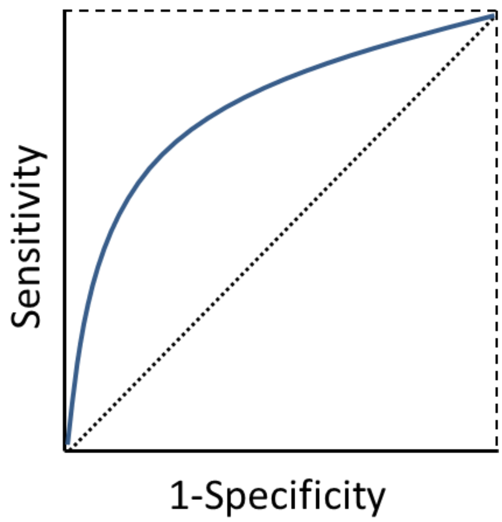
Sensitivity measures the proportion of true positives correctly identified as such, and specificity measures the proportion of true negatives correctly identified as such. For instance, if using a BMI cut-off of 25.0 kg/m^2, sensitivity reflects the proportion of people with diabetes who have a BMI above this value, while specificity reflects the proportion of people without diabetes who have a BMI below this value. It follows that 1 – specificity represents the proportion of individuals without diabetes who have a BMI above the 25 kg/m^2 cut-off value, and are incorrectly classified as having diabetes (false positives).

Figure 3: False positives and true positives of diabetes at a BMI cut-point of 25 kg/m^2 in a hypothetical population



In any test, there is a trade-off between optimising sensitivity and optimising specificity. This can be represented graphically using a ROC curve which is a plot of the true-positive rate (TPR, or sensitivity) against the false-positive rate (FPR, or 1 – specificity) for all possible test or measurement values. Useful cut-off points are those that provide for a high proportion of true positives while giving a low proportion of false positives. A ROC curve is also known as a “relative operating characteristic” curve, because it compares two operating characteristics (TPR and FPR) as the criterion changes. Thus, ROC is directly related to diagnostic decision-making. For the purposes of the current review, a ROC curve will provide data on true positives (the proportion true diabetes cases who have a BMI or WC above the cut-off) compared to false positives (the proportion of individuals above without diabetes who have a BMI or WC above the cut-off) identified as diabetic as the potential BMI or WC cut-off value varies.

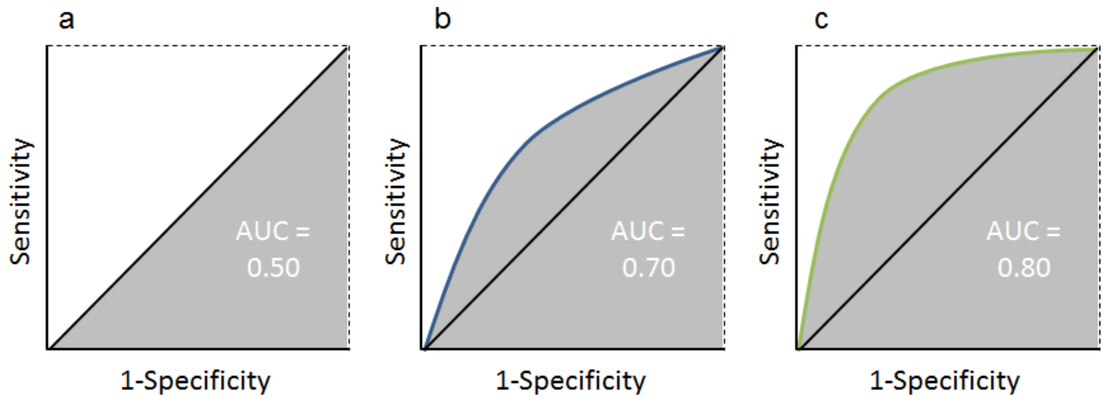
Figure 4: ROC Curve for a hypothetical test



Area under the curve

The area under the curve of the receiver operating characteristic curve (ROC AUC, or AUC) provides a single statistic to summarise the average performance of a test. That is, how well the range of sensitivities and specificities for a test that categories people as obese or overweight in a population, and correctly separates those people who already have or go on to develop a disease or complication. An AUC of 1.0 implies perfect performance or discriminatory ability, while an AUC of 0.50 indicates that a given test performs no better than chance at discriminating between health states. The discriminatory ability of different tests can be compared by ranking AUCs, with a higher AUC value indicating better performance. These rankings can be used to compare the average performance of different tests, or the average performance of a single test in different populations or circumstances.

Figure 5. Area under the curve for three hypothetical tests.
3a. A test with predictive or discriminatory ability no better than chance.
3b. A test with an average ability to correctly categorise diseased vs. non-diseased patients better than chance; On average Test B out-performs Test A.
3c. A test with an average ability to correctly categorise diseased vs. non-diseased patients better than chance. On average, Test C out-performs Tests B and A.

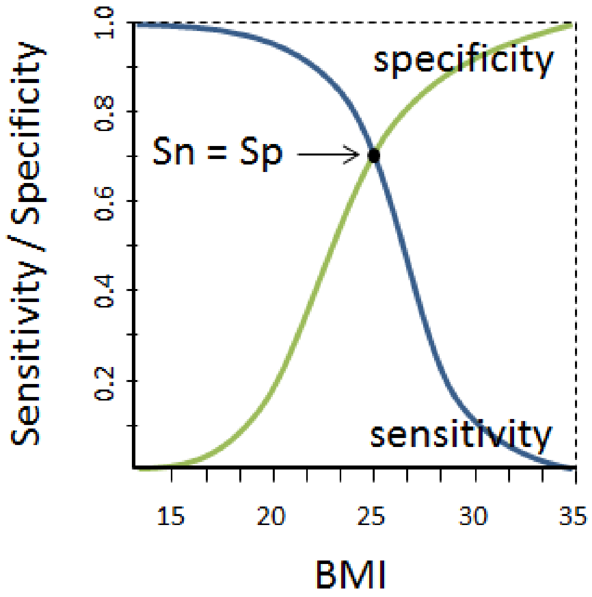


There is more than one way by which these concepts can be used as a rationale for developing 'optimal' BMI and waist circumference cut-off points in different populations. These include:

Sensitivity equal to specificity

This method is based on the intersection of lines on a plot of specificity and sensitivity (See Figure 6). This approach provides a similar proportion of false negatives to false positives. That is, based on BMI and WC, the number of people told they they are 'at risk' or 'unhealthy' when they are not will be similar to the number who are told they are 'healthy' or 'not at risk' when they are. This method grants equal weight to sensitivity and specificity.

Figure 6: Optimal BMI cut-off value, identified as the point where sensitivity equals specificity



Maximising sensitivity and specificity

Specific cut-off points can be based on optimal sensitivity and specificity for detecting a disease outcome (or for one or more cardiovascular and metabolic risk factors) in the population being studied. This approach provides the fewest false negatives or false positives and maximises the overall accuracy. Similar to the sensitivity equals specificity approach, this method grants equal weight to sensitivity and specificity.

Maximum sensitivity

If sensitivity is of paramount importance then cut-points can be set so that the sensitivity is maximised and the fewest false negatives are detected. This approach will result in more false postives. That is people who are told they are at risk or unhealthy because of their BMI or WC when they are not.

2.6.2 What are the ideal measures of obestity?

The National Obesity Observatory suggests for identifying individuals at increased risk of obesity-related ill health, there is evidence that measures of both general and central adiposity (that is BMI and waist circumference) should be used together.[48]

In terms of population monitoring, BMI has some advantages over measures of central adiposity. It involves less physical contact, and height and weight can be more reliably measured than waist circumference following basic training; measuring waist circumference reliably requires training in where and how to apply the tape measure. BMI is the most commonly used measure in national and international obesity prevalence statistics and so is most useful for historical trend analyses and international comparisons.[49]

Guidance from the National Institute for Health and Clinical Excellence (NICE) on obesity published in 2006 currently states that the assessment of the health risks associated with overweight and obesity should be based both on BMI and waist circumference in adults as described in Table 3.[50]

Table 3: Combining body mass index (BMI) and waist measurement to classify the risks of type 2 diabetes and cardiovascular disease.

BMI classification	**Waist circumference**		
	Low*	**High***	**Very high***
Normal weight	No increased risk	No increased risk	Increased risk
Overweight (25 to less than 30kg/m^2)	No increased risk	Increased risk	High risk
Obesity I (30 to less than 35kg/m^2)	Increased risk	High risk	Very high risk
Obesity II (35 to lessthan 40kg/m^2)	Very high risk	Very high risk	Very high risk
Obesity III (40kg/m^2 or more)	Very high risk	Very high risk	Very high risk
* For men, waist circumference of less than 94 cm is low, 94–102 cm is high and more than 102 cm is very high.For women, waist circumference of less than 80 cm is low, 80–88 cm is high and more than 88 cm is very high.			

Source: Obesity: the prevention, identification, assessment and management of overweight and obesity in adults and children, NICE guideline CG43.[50]

The World Health Organization (WHO) also advises that an individual's relative risk of obesity-related ill health can be more accurately classified using both BMI and waist circumference than by either alone.

2.6.3 Other measures of obestity

A recent report stressed, 'there is no straightforward relationship between obesity and ethnicity, with a complex interplay of factors affecting health in minority ethnic communities in the UK'. It adds that the validity of using current definitions of obesity for non-white ethnic groups is debatable (National Obesity Observatory 2011).

The waist-height or waist-stature ratio (WHtR or WSR) and waist-hip ratio (WHP) have been proposed as good measurements for use across all ethnic groups. It has been suggested that even in populations with low rates of obesity and moderate BMIs such as Japan and China, raised WHtR could be an important early indicator of lifestyle-related disorders and its measurement could be an important part of a public health approach to preventing diabetes and coronary heart disease.[51] Waist-to-height and waist-to-hip ratio were considered by NICE, but are not included in the current guidance due to resource constraints. These measures will be referred back to the Deparment of Health to be considered for future guidance.

2.7 Context for this review

There is uncertainty regarding which obesity measures are appropriate for use in black, Asian and other minority ethnc groups. In response to a World Health Organization report, the NHS Health Checks programme uses a BMI of 27.5 kg/m^2 as the trigger for preventive action among people of South Asian origin.[52] Neither the World Health Organization paper (2004) or the NICE obesity guidance considered there to be sufficient evidence to set separate cut-off points for the waist circumference of people of South Asian origin. However, lower cut-off points for BMI (23 kg/m^2) and waist circumference (90 cm for men and 80 cm for women) have subsequently been proposed in the International Diabetes Federation statement on type 2 diabetes prevention.[53] It is worth noting that and single BMI and waist circumference cut-off point may not be appropriate for all the different black, Asian and other minority ethnic groups.

3 Methods

3.1 Search and sifting criteria

Identifying the evidence

A group of experts were identified and canvassed to identify/recommend papers that were key to helping answer the referral received from DH. This process identified a set of 46 papers.

The NICE Information Services department undertook a Google Scholar search in February 2012. Each of the 46 references was entered into Google Scholar and then the 'cited by' function was used to determine which papers had cited the initial set. The 'cited by' function in Google Scholar was selected as it was determined that the papers citing our expert recommended key papers were also likely to focus on BMI and waist circumference cut-points in black, Asian and other minority ethnic groups. Furthermore, Google Scholar also indexes grey literature (such as theses) and therefore this does not require a separate search. The initial search was not limited by the type of studies being retrieved. Three of the 46 papers resulted in over 9,500 'cited by' hits and a decision was made to take a pragmatic approach to the results that were selected for screening. Google Scholar presents the 'cited by' hits in order of relevancy (although the algorithm used is unknown) and in the case of these three papers only the first 100 results were sifted. All of the 'cited by' hits were downloaded for the other 43 references. In total Google Scholar 'cited by' provided ~ 4,000 references. In addition to the topic expert recommended papers and the Google Scholar 'cited by' search, a call for evidence was issued in January, 2012 to include: published, in progress and grey literature. Published papers recommended by stakeholders during the scope consultation process were also included. The call for evidence and stakeholder consultation yielded an additional 99 references.

Selection criteria (Sift 1)

Prior to the expert panel meeting scheduled for March, 2012, an initial sift process of the Google Scholar ‘cited by’ search results was started with broad inclusion terms. This sifting process was carried out by two NICE CPHE analysts with the total number of references split equally between the two.

Studies were retained for further appraisal if the following criteria were met:

- **Population**: any black and minority ethnic population (world literature)
- **Type of study**: any type
- **Type of outcomes**: (BMI OR waist circumference) AND any chronic conditions / mortality.

To determine consistency a 10% check by each analyst of the other’s section was undertaken, using a random number table to identify the references to be checked. This identified some minor incongruence; each sub-section was re-evaluated with a final number of 737 (785 with 48 duplicates removed) ‘cited by’ references included. These were added to the 99 papers from the call for evidence/scope consultation and 46 expert recommended papers (Total: 882 – 10 duplicates = 872).

An expert panel was convened in March 2012 to review progress in identifying the evidence to date, to examine and refine the questions included in the scope/underpinning the evidence review, and to finalise the sifting inclusion criteria for identification of the papers to be passed onto the external review team.

Table 4: Summary of papers identified for second sift post expert panel meeting.

Sources	
Original papers identified by expert panel	46
Google Scholar searches	737 (785 - 48 duplicates)
Call for evidence and stakeholder consultation	99
Total	882
Duplicates	10
Duplicates removed	872

Appendix 1

Selection (Inclusion) criteria (Sift 2 n=872 papers)

The second sifting process was carried out by one NICE CPHE analyst. It was possible to exclude 262 papers from the information provided in the abstract. The full texts of 610 papers were retrieved before a decision was made. A total of 205 full text papers were passed to Bazian following this second stage screening.

The following criteria were used to identify inclusion papers for the external contractor undertaking the evidence review for this guidance.

Population:

- Black African/Caribbean
- South Asian
- Chinese
- Mixed race (*including above ethnic groups*)
- Middle Eastern (*to identify whether comparable risk with for example South Asian*)
  - UK studies most important
  - Worldwide acceptable, must include caveats
    - If possible split (home country, 1st generation, 2nd generation)

Study type:

- Large cross-sectional studies
- ROC analysis (*sensitivity analysis of particular interest*).
- Cohort studies (*prospective of particular interest*).
- Review articles (meeting population/outcome/analysis criteria)

Outcomes:

- Focus: Diabetes
- Plus: Fatal and non-fatal myocardial infarction, fatal and non-fatal stroke and mortality
- Metabolic Syndrome was included if diabetes/glucose related data was reported separately.

Analysis/Comparison:

- Focus cross-sectional studies: BAME vs. White population comparisons with a relevant health outcome. However, non-comparator studies also of interest.
- Focus ROC analysis: BAME vs. White population comparisons with a relevant health outcome. However, non-comparator studies also of interest.
- Focus cohort studies (prospective and retrospective): Average BMI and/or waist circumference at development of health outcome. BAME vs. White population comparisons preferred although, non-comparator studies also of interest.
- Percentage body fat studies (i.e. DXA) if BMI was a comparator and a relevant health condition the outcome of interest.

Exclusion criteria:

Population:

- Aboriginal Japanese
- North American Indian
- Hispanic

Study type:

- Consensus statements
- Randomised control trials/intervention studies

Outcomes:

- Hypertension only
- Hyperlipidaemia only
- Cardiovascular Disease (MI and/or Stroke not reported separately).
- Metabolic Syndrome was excluded if diabetes/glucose related data was NOT reported separately.

Table 5: Summary of evidence provided to contractor for further analysis and data extraction.

Of the 872:	
Analysed at full text Rejected at abstract by CPHE	610 262
Of the 610:	
Full text analysed by Contractor	205

3.2 Included studies and criteria for exclusion

After sifting and de-duplication, 205 unique studies were sent to Bazian, and these were further sifted based on the following inclusion criteria:

- Population (Black African/Caribbean, Chinese, South Asian, Middle Eastern, mixed race)
- Exposures (BMI and/or WC measured)
- Outcomes (diabetes, stroke, fatal or non-fatal myocardial infarction [MI], mortality).

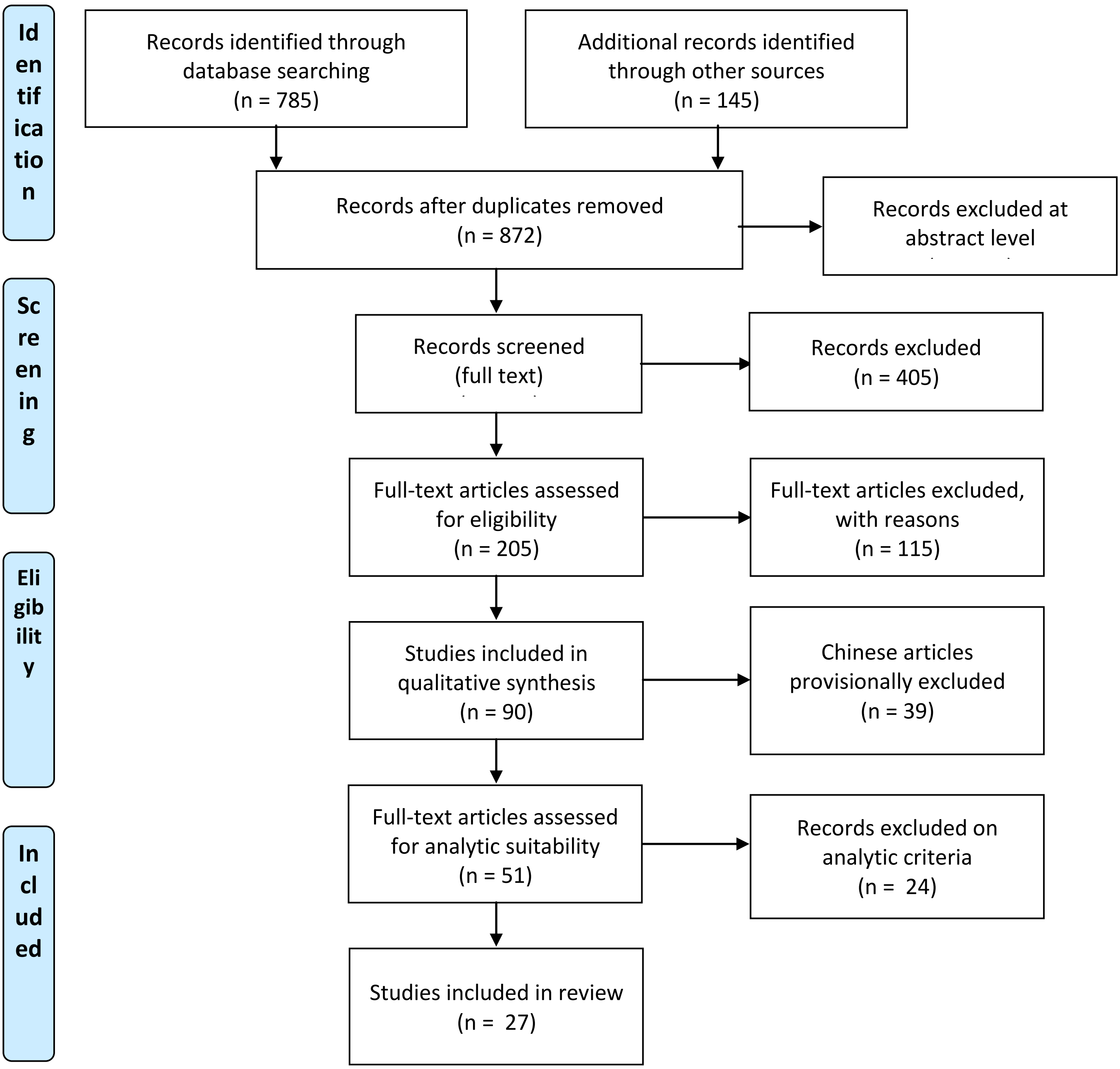
Studies were excluded if they were not published in English or if the study design rendered them unsuitable for data extraction, bringing the number of excluded papers to 115. The numbers excluded based on each criterion are listed below (figures sum to greater than 115 due to exclusions based on multiple criteria; see Appendix 1 for a summary of exclusions):

- Population: 19 studies
- Exposure: 16 studies
- Outcome: 67 studies
- Other (language, study design etc.): 28 studies

Following discussions with NICE, the remaining 90 studies were further sifted based on ethnicity. As Chinese ethinic groups make up a small proportion of the total UK population (see Table 1), studies conducted in non-Western setting with Chinese populations were further sifted. Studies conducted in Hong Kong included in the full review, and studies with other ethnic Chinese groups conducted in mainland China, Taiwan and other non-Western settings identified but not included for a full data extraction (See Appendix 2 for a list of these 39 studies). The remaining 51 studies were assessed based on analytical sifting criteria, and a further 24 studies were excluded, resulting in the inclusion of 27 studies in total.

Figure 7 summarises the final paper selection process.

Figure 7: PRISMA flow chart



3.3 Quality Assessment

All included studies were assessed using modified quality assessment checklists based on the tools from Appendices G and J of the 'Methods for the development of NICE public health guidance', and Appendices G and J of 'The guidelines manual 2009':

- Diagnostic checklist from NICE 'The guidelines manual 2009' Appendix G[54]
- Prognostic checklist from NICE 'The guidelines manual 2009' Appendix J[54]
- Quantitative correlation and association checklist, from NICE, 'Methods for the development of NICE public health guidance (second edition)' Appendix G[1]
- Review checklist from NICE 'Methods for the development of NICE public health guidance (second edition)' Appendix J[1]

Modifications for each of the checklists included:

- Diagnositic checklist – addition of an internal validity and UK applicability score
- Prognostic checklist – addition of an internal validity and UK applicability score
- Quantitative correlation and association checklist – addition of a UK applicability score; replacement of ++, +, -, NR and NA scoring options with Yes, No, Unclear and N/A; removal of questions 2.1 to 2.3, 3.3 to 3.4 and 4.1, as they were not considered applicabile to the review questions.
- Review checklist – addition of a summary quality score and a UK applicability score; replacement of ++, +, -, NR and NA with Yes, No, Unclear and N/A.

Based on the checklist answers, each study was given an overall study quality rating, reported using a summary score, of [++] for strong quality, [+] for moderate quality and [-] for weak quality.

3.4 Applicability Assessment

Given the nature of the review questions, and the various settings of the identified evidence, an additional applicability summary score was given. This score rated the study's generalisability to black, Asian and minority ethnic populations in the UK, and was reported using the same [++] strong, [+] moderate and [-] weak scoring system as the quality summary score outlined in Section 3.3.

Applicability of the evidence was assessed according to the methods for the development of NICE public health guidance.[1] Population, setting and outcome characteristics as summarised in Table 6 were considered, and the extent to which these factors aligned with the current review questions was assessed.

Table 6: NICE methods for assessing applicability

Area of applicability	Characteristics
Population	Age, sex/gender, race/ethnicity, disability, sexual orientation/gender identity, religion/beliefs, socioeconomic status, health status
Setting	Country, geographical context, healthcare/delivery system, legislative, policy, cultural, socioeconomic and fiscal context
Outcome	Appropriate/relevant, follow-up periods, important health effects.

Source: NICE. Methods for the development of NICE public health guidance (second edition). 2009.[1]

In addition, the following characteristics were considered to be of particular relevance to the current review:

- Population: mean baseline BMI and/or WC, assessed against data UK data presented in Table 7. Ethnicities for which no UK specific mean BMI or WC figures are available were assessed against the UK general population figures.
- Setting: UK or Western setting vs. non-Western setting

- Outcomes: diabetes diagnostic methods and criteria, assessed against current criteria outlined in Table 8.

Table 7: Mean body mass index and waist circumference by ethnic group, 2004, England

Ethnic Group	Mean BMI (95% CI) Males (kg/m^2)	Mean BMI (95% CI) Females (kg/m^2)
Black Caribbean	27.1 (26.6 to 27.6)	28.0 (26.4 to 27.8)
Black African	26.4 (25.8 to 27.0)	28.8 (25.5 to 27.3)
Indian	25.8 (25.3 to 26.3)	26.2 (25.4 to 26.2)
Pakistani	25.9 (25.4 to 26.4)	27.1 (25.3 to 26.5)
Bangladeshi	24.7 (24.3 to 25.1)	25.7 (24.1 to 25.3)
Chinese	24.1 (23.6 to 24.6)	23.2 (23.6 to 24.6)
General Population	27.1 (26.9 to 27.3)	26.8 (26.6 to 27.0)
	Mean WC (95% CI) Males (cm)	**Mean WC (95% CI) Females (cm)**
Black Caribbean	92.5 (90.5 to 94.5)	88.4 (86.2 to 90.6)
Black African	90.6 (88.3 to 92.9)	90.2 (87.5 to 92.9)
Indian	93.0 (91.4 to 94.6)	83.9 (82.4 to 85.4)
Pakistani	95.0 (93.3 to 96.7)	87.7 (85.9 to 89.5)
Bangladeshi	88.7 (86.7 to 90.7)	85.7 (83.6 to 87.8)
Chinese	86.8 (84.8 to 88.8)	77.6 (76.1 to 79.1)
General Population	96.5 (96.1 to 96.9)	86.4 (86.0 to 86.8)

Source: Adapted from Joint Health Surveys Unit (2005) Health Survey for England 2004. The Health of Minority Ethnic Groups. Department of Health: London.[45]

Table 8: Type 2 diabetes diagnostic criteria

Measure	Criteria
Random venous plasma glucose concentration	≥11.1 mmol/L
Fasting venous plasma glucose concentration (FPG)	≥7.0 mmol/L
Venous plasma glucose concentration 2 hours after 75g anhydrous glucose challenge in an oral glucose tolerance test (OGTT)	≥11.1 mmol/L
Glycated haemoglobin (HbA1c)	6.5%

Source: NICE Public Health Guidance 35. Preventing type 2 diabetes. 2011.[26]

Scores are presented as quality/applicability. For instance, Chiu 2011 was assessed using the modified quantitative correlation and association checklist. This study had moderate quality [+]; it adequately addressed most checklist questions, but as it was unclear whether all likely confounders were controlled for, and whether the outcome measures were complete, it did not received a strong [++] summary quality rating. This study was rated as having moderate applicability [+] to UK populations; it was carried out in a western country (Canada) and mean BMI across ethnicity subgroups was similar to the UK figures, and diabetes cases were identified using a population based registry. However, the methods of identifying diabetes cases were unclear. Overall, Chiu 2011 was rated as having a moderate summary validity score and a moderate summary applicability score [+/+].

The checklists are presented in Appendix 3; the original NICE checklists appear at the beginning of each section, followed by the modified checklist for each appraised study.

3.5 Summarising the evidence and evidence statements

Study characteristics and data were extracted from the included studies by a research analyst at Bazian and checked by another. Data extraction tables are provided in Appendix 4, and include descriptions of the studies' aims, population, methods and results. The review findings were synthesised narratively and used to generate evidence statements. The statements reflect the strength (quality, quantity and consistency) of the evidence, as well as the applicability to black, Asian and minority ethnic groups in the UK.

Evidence statements for Question 1 are based on cohort studies and reviews that either provided ratios (HR/OR/RR) between black, Asian and minority ethnic groups and white populations, provided AUC for BMI and/or WC in black, Asian and minority ethnic populations, or provided within group ratios (HR/OR/RR) between BMI and WC.

Evidence statements for Question 2 are based on results synthesised from cohort or cross sectional studies which provided within group ratios (HR/OR/RR) between BMI and WC categories in black, Asian and minority ethnic populations. Cut-off values for normal BMI or WC were taken as the upper (or lower) boundary of the stratum above (or below) which the risk association became statistically significant (based on 95% CIs that spanned 1.0).[9]

Evidence statements for Question 3 are based on cohort and cross sectional studies in black, Asian and ethnic minority groups that utilised ROC analysis to identify an optimised BMI or WC cut-off, or provide corresponding sensitivity figures across a range of BMI or WC values.

Finally, evidence statements for Question 4 and based cohort or cross sectional studies that presented graphs with risk curves for incident or prevalent outcomes by BMI or WC (as either a continuous or categorical variables) by ethnicity, provided data on outcome prevalence by BMI or WC (as either continuous or categorical variables) by ethnicity, or reported risk-equivalent BMI or WC values compared to white populations.

Evidence statements are provided for each question, with separate statements based on exposure (BMI, WC), ethnicity (black, South Asian, Middle Eastern, Chinese, mixed), and outcome (diabetes, other). No studies were identified related to individuals of mixed ethnic origin; however, several studies pooled data on populations with multiple scoped ethnicities. These studies have been included, and are referred to using the term mixed ethnic populations throughout the report.

The overall strength of evidence was summarised as:

- No evidence
- Weak evidence – for statements based on quality summary scores of [-]
- Moderate evidence – for statements based on quality summary scores of [+]
- Strong evidence – for statements based on quality summary scores of [++]
- Inconsistent evidence – for statements based on moderate to strong evidence with conflicting results

4 Results

4.1 Question 1

How accurate are body mass index (BMI) and waist circumference in predicting the future risk of type 2 diabetes, fatal/non-fatal myocardial *infarction or stroke and overall mortality among adults from black, Asian and other minority ethnic groups living in the UK compared to the white or general UK population?*

Data was extracted for cohort studies which:

- Provided ROC AUC for BMI and/or WC in black, Asian and minority ethnic populations (see Section 2.6.1 for a description of ROC analysis)
- Provided within group ratios (HR/OR/RR) between BMI and WC categories

4.1.1 People of black descent

Two cohort studies (MacKay, 2009 [quality +/ applicability +])[2] and (Sargeant, 2002 [+/-])[3] examined the predictive value of BMI or WC for incident (i.e. new cases) diabetes in black populations. One study was conducted in Canada, and the other in Jamaica. Both studies assess BMI as well as WC, and reported diabetes as an outcome. The studies evaluated the prognostic power of BMI and WC using ROC analysis.

MacKay, 2009.[2] 282 participants in the black subgroup (baseline BMI not reported; mean follow-up 5.2 years) had a ROC AUC for the prediction of diabetes of 0.616 compared to a ROC AUC of 0.734 amongst 430 white participants. The corresponding ROC AUCs for WC were 0.630 amongst black participants compared to 0.716 amongst white participants. This indicates that the predictive ability of BMI and WC is better amongst white participants than black participants. It should be noted, however, that the 95% CI for these AUCs are not provided, thus differences may not reflect a statistically significant difference in AUCs.

This study has moderate applicability to the UK. The participants were drawn from a Western population, however, the criteria used to define diabetes do not align with current UK clinical practice.

Sargeant, 2002.[3] 728 participants of African ancestry (mean baseline BMI 23.5 males, 27.7 females; mean follow-up 4 years) had an ROC AUC for the prediction of diabetes of 0.74 (males) and 0.62 (females). The AUC for WC was 0.78 (males) and 0.61 (females) in this population.

This study has weak applicability to the UK. Male participants had lower mean BMI than similar ethnic groups in the UK (female measures were similar), and the study included self-reported diabetes diagnosis as a criterion for assessing incident diabetes, which may misclassify cases compared to current UK clinical practice, although the direction of such potential misclassification is unknown.

See Tables 9 and 10 for a summary of results for Question 1.

Evidence statement Q1.1: BMI as predictor of diabetes risk in black populations

ROC analysis indicates that BMI can predict incident diabetes in black populations.

Q1.1.a: UK or Western Countries

Moderate evidence was found from one cohort study (MacKay, 2009 [quality +/ applicability +])[2] indicating that the predictive power (ROC AUC) of BMI for diabetes in black populations was 0.616 compared to 0.734 among white populations in the USA.

This study had moderate applicability to the UK.

Q1.1.b: Other Countries

Moderate evidence was found from one cohort study (Sargeant, 2002 [+/-])[3] that the predictive power (ROC AUC) of BMI for diabetes in black males was 0.74, and 0.62 in black females.

This study had weak applicability to the UK.

Evidence statement Q1.2: WC as predictor of diabetes risk in black populations

ROC analysis indicates that WC can predict incident diabetes in black populations.

Q1.2.a: UK or Western Countries

Moderate evidence was found from one cohort study (MacKay, 2009 [+/+])[2] indicating that the predictive power (ROC AUC) of WC for diabetes in black populations was 0.630 compared to 0.716 among white populations in the USA.

This study had moderate applicability to the UK.

Q1.2.b: Other Countries

Moderate evidence was found from one cohort study (Sargeant, 2002 [+/-])[3] that the predictive power (ROC AUC) of WC for diabetes in black males was 0.78, and 0.61 in black females.

This study had weak applicability to the UK.

No evidence – Black populations

Evidence statement Q1.3: BMI as predictor of myocardial infarction, stroke or mortality in black populations

No evidence was found relevant to BMI as a predictor of myocardial infarction, stroke or mortality in black populations.

Evidence statement Q1.4: WC as predictor of myocardial infarction, stroke or mortality in black populations

No evidence was found relevant to WC as a predictor of myocardial infarction, stroke or mortality in black populations.

4.1.2 People of South Asian descent

No studies were identified that assessed the ability of BMI or WC to predict diabetes, myocardial infarction, stroke or mortaility in South Asian populations in the UK.

Evidence statement Q1.5: BMI as predictor of diabetes risk in South Asian populations

No evidence was found relevant to BMI as a predictor of diabetes in South Asian populations.

Evidence statement Q1.6: BMI as predictor of myocardial infarction, stroke or mortality in South Asian populations

No evidence was found relevant to BMI as a predictor of myocardial infarction, stroke or mortality in South Asian populations.

Evidence statement Q1.7: WC as predictor of diabetes risk in South Asian populations
No evidence was found relevant to WC as a predictor of diabetes in South Asian populations.

Evidence statement Q1.8: WC as predictor of myocardial infarction, stroke or mortality in South Asian populations
No evidence was found relevant to WC as a predictor of myocardial infarction, stroke or mortality in South Asian populations.

4.1.3 People of Middle Eastern descent

Four cohort studies (Hadaegh, 2006 [+/+]),[5] (Hadaegh, 2009 [+/+]),[6] (Janghorbani, 2009 [+/-])[7] and (Mansour, 2007 [++/+])[4] examined the predictive value of BMI or WC for incident diabetes in Middle Eastern populations. None of the studies were conducted in a UK or other Western setting. All four studies assessed both BMI and WC and included diabetes as an outcome. The four studies evaluated the predictive power of BMI and WC for diabetes using ROC analysis,

Hadaegh, 2006.[5] 1,852 male participants (mean baseline BMI 25.9 to 28.1 kg/m^2; mean baseline WC 88.7 to 96.6 cm; mean follow-up 3.6 years) in Iran had a ROC AUC for BMI's ability to predict of diabetes of 0.693.

This study has moderate applicability to UK. It was conducted in a non-Western setting; however, the diabetes diagnostic criteria used in the study align with current UK clinical practice. The range of mean baseline BMIs and WCs were similar to the means seen in the UK general population.

Hadaegh, 2009.[6] 2,801 female participants (mean baseline BMI 27.4 to 30.3 kg/m^2; mean baseline WC 87.2 to 95.9 cm; mean follow-up 3.5 years) in Iran had a ROC AUC for the ability of BMI to predict diabetes of 0.69.

This study had moderate applicability to UK. It was conducted in a non-Western setting; however, the diabetes diagnostic criteria used in the study align with current UK clinical practice. The range of mean baseline BMIs and WCs were similar to the means seen in the UK general population.

Janghorbani, 2009.[7] 704 participants (mean baseline BMI 28.9 to 30.9 kg/m^2; mean baseline WC 88.3 to 92.0 cm; mean follow-up 2.3 years) in Iran had a ROC AUC for the prediction of diabetes by BMI of 0.625 (95% CI 0.556 to 0.693). The WC ROC AUC was 0.620 (95% CI 0.557 to 0.683).

This study had weak applicability to UK. It was conducted in a non-Western clinical setting, and included participants with a first-degree relative with diabetes. These participants are unlikely to be representative of the general Middle Eastern population in the UK, as they are all have a definitive risk factor for diabetes.

Mansour, 2007.[4] 13,730 participants in Iraq (mean baseline BMI 26.20 kg/m^2; mean baseline WC 91.0 cm; mean follow-up 5 years) had a ROC AUC for the prediction of diabetes by BMI of 0.66 (95% CI 0.64 to 0.68) amongst males and 0.61 (95% CI of 0.59 to 0.64) amongst females. The ROC AUC of WC was 0.71 (95% CI 0.69 to 0.73) amongst males and 0.69 (95% CI 0.66 to 0.71) amongst females.

This study had moderate applicability to UK. It was conducted in a non-Western setting, however, diabetes diagnostic criteria align with current UK clinical practice, and participants mean baseline BMI and WC were similar to that seen in the UK general population.

See Tables 9 and 10 for a summary Question 1 results.

Evidence statement Q1.9: BMI as predictor of diabetes risk in Middle Eastern populations

In Middle Eastern populations, ROC analysis indicates that BMI can predict incident diabetes, and has an AUC ranging from approximately 0.61 to 0.69

Q1.9.a: UK or Western Countries

No evidence was found relevant to BMI as a predictor of diabetes in Middle Eastern populations in the UK or other western settings

Q1.9.b: Other Countries

Moderate to strong evidence was found from four cohort studies (Mansour, 2007 [++/+]),[4] (Hadaegh, 2006 [+/+]),[5] (Hadaegh, 2009 [+/+])[6] and (Janghorbani, 2009 [+/-])[7] that the predictive power (ROC AUC) of BMI for diabetes ranged from 0.61 to 0.69 in Middle Eastern populations.

These studies had weak to moderate applicability to the UK.

Evidence statement Q1.10: WC as predictor of diabetes risk in Middle Eastern populations

Q1.10.a: UK or Western Countries

No evidence was found relevant to WC as a predictor of diabetes in Middle Eastern populations in the UK or other western settings.

Q1.10.b: Other countries

Moderate to strong evidence was found from two cohort studies (Mansour, 2007 [++/+])[4] and (Janghorbani, 2009 [+/-])[7] that the predictive power (ROC AUC) of WC for incident diabetes ranged from 0.62 to 0.71 in Middle Eastern populations.

These studies had weak to moderate applicability to the UK.

No evidence – Middle Eastern populations

Evidence statement Q1.11: BMI as predictor of myocardial infarction, stroke or mortality in Middle Eastern populations

No evidence was found relevant to BMI as a predictor of myocardial infarction, stroke or mortality in Middle Eastern populations.

Evidence statement Q1.12: WC as predictor of myocardial infarction, stroke or mortality in Middle Eastern populations

No evidence was found relevant to WC as a predictor of myocardial infarction, stroke or mortality in Middle Eastern populations.

4.1.4 People of Chinese descent

No studies were identified that examined the predictive value of BMI or WC for diabetes, MI, stroke or mortality in a Chinese population.

Evidence statement Q1.13: BMI as predictor of diabetes risk in Chinese populations
No evidence was found relevant to BMI as a predictor of diabetes in Chinese populations.

Evidence statement Q1.14: BMI as predictor of myocardial infarction, stroke or mortality risk in Chinese populations
No evidence was found relevant to BMI as a predictor of myocardial infarction, stroke or mortality in Chinese populations.

Evidence statement Q1.15: WC as predictor of diabetes risk in Chinese populations
No evidence was found relevant to WC as a predictor of diabetes in Chinese populations.

Evidence statement Q1.16: WC as predictor of myocardial infarction, stroke or mortality risk in Chinese populations
No evidence was found relevant to WC as a predictor of myocardial infarction, stroke or mortality in Chinese populations.

4.1.5 Mixed ethnic populations

No studies were identified that examined the predictive value of BMI or WC for diabetes, MI, stroke or mortality in a mixed ethnic population.

Evidence statement Q1.17: BMI as predictor of diabetes risk in mixed ethnic populations
No evidence was found relevant to BMI as a predictor of diabetes in mixed ethnic populations.

Evidence statement Q1.18: BMI as predictor of myocardial infarction, stroke or mortality risk in mixed ethnic populations

No evidence was found relevant to BMI as a predictor of myocardial infarction, stroke or mortality in mixed ethnic populations.

Evidence statement Q1.19: WC as predictor of diabetes risk in mixed ethnic populations

No evidence was found relevant to WC as a predictor of diabetes in mixed ethnic populations.

Evidence statement Q1.20: WC as predictor of myocardial infarction, stroke or mortality risk in mixed ethnic populations

No evidence was found relevant to WC as a predictor of myocardial infarction, stroke or mortality in mixed ethnic populations.

Appendix 1

Table 9: Question 1 results summary. Predictive ability of BMI.

Question 1 BMI	AUC for BMI									
	Black		South Asian		Middle Eastern		Chinese		White	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
MacKay, 2009	0.616								0.734	
Sargeant, 2002	0.74	0.62								
Janghorbani, 2009					0.63					
Hadaegh, 2006					0.69	-				
Hadaegh, 2009					-	0.69				
Mansour, 2007					0.66	0.61				
Total Range	0.616-0.74	0.616-0.62			0.63-0.69	0.61-0.69			0.734	
Applicable Range	**0.616**				**0.66-0.69**	**0.61-0.69**			**0.734**	

Table 10: Question 1 results summary. Predictive ability of WC.

Question 1 WC	AUC for WC									
	Black		South Asian		Middle Eastern		Chinese		White	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
MacKay, 2009	0.630								0.716	
Sargeant, 2002	0.78	0.61								
Janghorbani, 2009					0.62					
Hadaegh, 2006					-	-				
Hadaegh, 2009					-	-				
Mansour, 2007					0.71	0.69				
Total Range	0.63-0.78	0.61-0.63			0.62-0.71	0.62-0.69			0.716	
Applicable Range	**0.630**				**0.71**	**0.69**			**0.716**	

4.2 Question 2:

What are the BMI and waist circumference cut-off points indicating a healthy range for these measures among adults from different black, Asian and other minority ethnic groups living in the UK?

Data was extracted for cohort or cross sectional studies which:

- Provided within group ratios (HR/OR/RR) between BMI and WC categories; cut-off values for normal BMI or WC were taken as the upper (or lower) boundary of the stratum above (or below) which the risk association became statistically significant (based on 95% CIs that spanned 1.0)[9]

4.2.1 People of black descent

One cross sectional study (Taylor, 2010 [++/+])[8] examined the association between BMI and prevalent diabetes amongst black populations, using within group ORs compared to a reference BMI category. This study included a similar within group OR analysis for a white population.

Taylor, 2010.[8] 4,030 participants in the US black subgroup (mean baseline BMI not reported) were stratified according to BMI. The association between BMI and prevalent diabetes was compared for each BMI catetory to a reference category of 18.5 to 25.0 kg/m^2 among participants aged 35 to 54 years. The risk of diabetes was significantly higher among participants with a BMI of 30 to 34.9 kg/m^2 and 35 to 50 kg/m^2 compared to the reference category, indicating that 29.9 kg/m^2 may represent an appropriate upper threshold for a healthy BMI range among these participants with regards to diabetes risk. Among white participants, the association between BMI and diabetes, compared to a reference category of 18.5 to 25.0 kg/m^2 was significant in participants with a BMI between 25.0 and 29.9 kg/m^2, suggesting that in the white subgroup, an appropriate upper limit for a healthy BMI range with regards to diabetes risk is 24.9 kg/m^2. The ORs for prevalent diabetes compared to the normal BMI group were consistently higher in the white subgroup compared to the black subgroup, however, this difference was only significant in the highest BMI category (35.0 to 50.0 kg/m^2).

This study has moderate applicability to the UK. It was conducted in a Western country, however, diabetes case status were assessed in part by medication use, which could misclassify cases compared to current UK clinical practice.

See Table 11 for a summary of results for Question 2.

Evidence statement Q2.1: Healthy BMI cut-points for black populations (Type 2 Diabetes)

Moderate evidence from one cross sectional study (Taylor, 2010 [++/+])[8] suggests that 29.9 kg/m^2 may be an appropriate upper boundary for a healthy BMI range in black populations, compared to 24.9 kg/m^2 in white participants. No lower boundary was identified.

This study had moderate applicability to the UK.

No evidence – Black populations

Evidence statement Q2.2: Healthy BMI cut-points for black populations (myocardial infarction, stroke and mortality)

No evidence was found relevant to healthy BMI cut-points for myocardial infarction, stroke or mortality in black populations.

Evidence statement Q2.3: Healthy WC cut-points for black populations (Type 2 Diabetes)

No evidence was found relevant to healthy WC cut-points for diabetes in black populations.

Evidence statement Q2.4: Healthy WC cut-points for black populations (myocardial infarction, stroke and mortality)

No evidence was found relevant to healthy WC cut-points for myocardial infarction, stroke or mortality in black populations.

4.2.2 People of South Asian descent

One cross sectional study (Snehalatha, 2003 [-/-])[9] conducted in India examined the association between BMI, WC and diabetes amongst South

Asian populations. The study used within group HRs compared to a reference BMI category to assess diabetes risk.

Snehalatha, 2003.[9] 10,025 participants in India (mean baseline BMI 24.4 male and 23.6 female; mean baseline WC 80.7 male and 79 female) were assessed for prevalent diabetes. Both male and female participants above a BMI category of 23 to 24 kg/m^2 were at an increased risk of diabetes compared to those with a BMI less than 20 kg/m^2; male OR 2.27 (95% CI 1.29 to 3.99), female OR 2.03 (95% CI 1.19 to 3.46). This indicates that 22.9 kg/m^2 may be an appropriate upper bound for a healthy BMI range in this population. Diabetes risk was significantly higher for male participants above a WC category of 85 to 90 cm, OR 1.98 (95% CI 1.27 to 3.1). A significant increase in diabetes risk was seen in female participants above a WC category of 80 to 85 cm, OR 1.8 (95% CI 1.12 to 2.83). This suggests that an appropriate upper bound for a healthy WC range in this population would be 84.9 amongst males and 79.9 amongst females.

This study has weak applicability to the UK. It was conducted in a non-Western setting, and was comprised of participants with low baseline BMI and WC compared to Indian populations within the UK. Diabetes was assessed in a manner that does not align with current UK clinical practice.

See Table 11 for a summary of results for Question 2.

Evidence statement Q2.5: Healthy BMI cut-points for South Asian populations (Type 2 Diabetes)

Q2.5.a: UK and Western Countries

No evidence was found relevant to healthy BMI cut-points for diabetes in South Asian populations in Western settings.

Q2.5.b: Other Countries

Weak evidence from one cross sectional study conducted in India (Snehalatha, 2003 [-/-])[9] suggest that 22.9 kg/m^2 may represent an appropriate upper boundary for a healthy population BMI range with regards to diabetes; no lower boundary was identified.

This study had weak applicability to the UK.

Evidence statement Q2.6: Healthy WC cut-points for South Asian populations (Type 2 Diabetes)

Q2.6.a: UK and Western Countries

No evidence was found relevant to healthy WC cut-points for type 2 diabetes in South Asian populations in the UK or other Western settings.

Q2.6.b: Other Countries

Weak evidence from one cross sectional study conducted in India (Snehalatha, 2003 [-/-])[9] suggests that a healthy population WC is less than 85 cm for South Asian men, and less than 80 cm for South Asian women.

This study had weak applicability to the UK.

No evidence – South Asian populations

Evidence statement Q2.7: Healthy BMI cut-points for South Asian populations (myocardial infarction, stroke or mortality)

No evidence was found relevant to healthy BMI cut-points for myocardial infarction, stroke or mortality in South Asian populations.

Evidence statement Q2.8: Healthy WC cut-points for South Asian populations (myocardial infarction, stroke or mortality)

No evidence was found relevant to WC as a predictor of myocardial infarction, stroke or mortality in South Asian populations.

4.2.3 People of Middle Eastern descent

Two cohort studies (Hadaegh, 2006 [+/+])[5] and (Hadaegh, 2009 [+/+])[6] examined the association between BMI and WC and incident diabetes in Middle Eastern populations. Both studies were conducted in Iran.

Hadaegh, 2006.[5] 1,852 male participants (mean BMI 25.9 to 28.1 kg/m^2; mean WC 88.7 to 96.6 cm; mean follow-up 3.6 years) in Iran were stratified based on their baseline BMI and WC. Odds ratios for incident diabetes were calculated, using the lowest category (≤22.9 kg/m^2 or ≤ 80.9 cm) as a reference. There was no significant increase in odds of developing diabetes amongst participants in any of the three highest quartiles of BMI. In the highest quartile of WC (≥97 cm) there was a borderline significant increase in risk of developing diabetes OR 3.0 (95% CI 1.0 to 8.9). This study found no appropriate bounds for a healthy BMI range or a healthy population WC in terms of diabetes.

This study had moderate applicability to UK. It was conducted in a non-Western setting; however, the diabetes diagnostic criteria used in the study align with current UK clinical practice. The range of mean baseline BMIs and WCs were similar to the means seen in the UK general population.

Hadaegh, 2009.[6] 2,801 female participants (mean BMI 27.4 to 30.3 kg/m^2; mean WC 87.2 to 95.9 cm; mean follow-up 3.5 years) in Iran were stratified based on their baseline BMI and WC. There was a significant increase in odds of developing diabetes amongst participants in the highest BMI quartile of 30.6 to 48 kg/m^2, OR 3.1 (95% CI 1.3 to 7.2), suggesting that a BMI of 30.5 kg/m^2 may be an appropriate upper boundary for a healthy BMI range. Above the third quartile of WC ≥87 cm there was a significant increase in the risk of developing diabetes, OR 3.7 (95% CI 1.4 to 9.9). This suggests a WC of 86.9 cm may represent appropriate healthy population WC in terms of absence of diabetes) for women in this setting.

This study had moderate applicability to UK. It was conducted in a non-Western setting; however, the diabetes diagnostic criteria used in the study align with current UK clinical practice. The range of mean baseline BMIs and WCs were similar to the means seen in the UK general population.

Significant increases in the risk of diabetes occur at a BMI above 30.5 kg/m^2 and a WC above 87 cm among Middle Eastern women in non-Western settings. See Table 11 for a summary of results for Question 2.

Evidence statement Q2.9: Healthy BMI cut-points for Middle Eastern populations (Type 2 Diabetes)

Q2.9.a: UK and Western Countries

No evidence was found relevant to healthy BMI cut-points for diabetes in Middle Eastern populations in Western settings.

Q2.9.b: Other Countries

Moderate evidence from two cohort studies, one in men and one in women, (Hadaegh, 2006 [+/+])[5] and (Hadaegh, 2009 [+/+])[6] conducted in Iran suggest that an appropriate upper bound for a healthy BMI range with regards to diabetes in women may be as high as 30.5 kg/m^2; no lower boundary was identified. No healthy range was identified for males.

These studies had moderate applicability to the UK.

Evidence statement Q2.10: Healthy WC cut-points for Middle Eastern populations (Type 2 Diabetes)

Q2.10.a: UK and Western Countries

No evidence was found relevant to healthy WC cut-points for diabetes in Middle Eastern populations in the UK or other Western settings.

Q2.10.b: Other Countries

Moderate evidence from two studies, one in men and one in women, (Hadaegh, 2006 [+/+])[5] and (Hadaegh, 2009 [+/+])[6] conducted in Iran identified nohealthy WC cut-point for men. For women there was a significant increase in risk of diabetes above 87cm, suggesting that 86.9 cm may represent an appropriate healthy WC cut-off in Middle Eastern female populations.

These studies had moderate applicability to the UK.

No evidence – Middle Eastern populations

Evidence statement Q2.11: Healthy BMI cut-points for Middle Eastern populations (myocardial infarction, stroke and mortality)

No evidence was found relevant to healthy BMI cut-points for myocardial infarction, stroke and mortality in Middle Eastern populations.

Evidence statement Q2.12: Healthy WC cut-points for Middle Eastern populations (myocardial infarction, stroke and mortality)
No evidence was found relevant to healthy WC cut-points for myocardial infarction, stroke and mortality in Middle Eastern populations.

4.2.4 People of Chinese descent

One cross sectional study (Thomas, 2004 [+/+])[10] examined the association between BMI and WC and incident diabetes in a Chinese population. The study was conducted in Hong Kong.

Thomas, 2004.[10] 2,893 participants in Hong Kong with a mean baseline BMI 24.1 kg/m^2 and WC 79.1 cm were stratified according to BMI and WC quartile. Participants above the second BMI quartile (22.11 to 23.52 kg/m^2) had significantly increased risk of incident diabetes, OR 1.8 (95% CI 1.2 to 2.5), while participants above the third WC quartile (73.3 to 78.3 cm) were at significantly increased risk, OR 2.2 (95% CI 1.5 to 3.3). This indicates that a BMI of 22.1 kg/m^2 and a WC of 73.1 cm may be appropriate upper bounds of a healthy BMI range in this population.

This study had moderate applicability to the UK. It included participants from non-Western setting, however, mean baseline BMI was similar to that seen among Chinese populations in the UK and diabetes diagnostic criteria align with current UK practice.

See Table 11 for a summary of results for Question 2.

Evidence statement Q2.13: Healthy BMI cut-points for Chinese populations (Type 2 Diabetes)
Q2.13.a: UK and Western Countries

No evidence was found relevant to healthy BMI cut-points for diabetes in Chinese populations in the UK or other Western settings.

Q2.13.b: Other Countries

There is moderate evidence from one cross sectional study conducted in Hong Kong (Thomas, 2004 [+/+])[10] that 22.1 kg/m^2 is an appropriate upper bound for a healthy BMI range in this population; no lower boundary was identified.

This study had moderate applicability to the UK.

Evidence statement Q2.14: Healthy WC cut-points for Chinese populations (Type 2 Diabetes)

Q2.14.a: UK and Western Countries

No evidence was found relevant to healthy WC cut-points diabetes in Chinese populations in the UK or other Western settings.

Q2.14.b: Other Countries

There is moderate evidence from one cross sectional study conducted in Hong Kong (Thomas, 2004 [+/+])[10] that 73.1 cm is an appropriate cut-point for a for a healthy population WC.

This study had moderate applicability to the UK.

No evidence – Chinese populations

Evidence statement Q2.15: Healthy BMI cut-points for Chinese populations (myocardial infarction, stroke or mortality)

No evidence was found relevant to healthy BMI cut-points for myocardial infarction, stroke or mortality in Chinese populations.

Evidence statement Q2.16: Healthy WC cut-points for Chinese populations (myocardial infarction, stroke or mortality)

No evidence was found relevant to healthy WC cut-points for myocardial infarction, stroke or mortality in Chinese populations.

4.2.5 Mixed ethnic populations

No studies were identified that were relevant to healthy BMI or WC cut-points diabetes in mixed ethnic populations.

Evidence statement Q2.17: Healthy BMI cut-points for mixed ethnic populations (Type 2 Diabetes)

No evidence was found relevant to healthy BMI cut-points for diabetes in mixed ethnic populations.

Evidence statement Q2.18: Healthy BMI cut-points for mixed ethnic populations (myocardial infarction, stroke or mortality)

No evidence was found relevant to healthy BMI cut-points for myocardial infarction, stroke or mortality in mixed ethnicpopulations.

Evidence statement Q2.19: Healthy WC cut-points for mixed ethnic populations (Type 2 Diabetes)

No evidence was found relevant to healthy WC cut-points for diabetes in mixed ethnic populations.

Evidence statement Q2.20: Healthy WC cut-points for mixed ethnic populations (myocardial infarction, stroke or mortality)

No evidence was found relevant to healthy WC cut-points for myocardial infarction, stroke or mortality in mixed ethnic populations.

Table 11: Question 2 results summary. Healthy BMI and WC.

Question 2 BMI	Healthy BMI Range (kg/m^2)																			
	Black				South Asian				Middle Eastern				Chinese				White			
	Male*		Female*		Male		Female		Male		Female		Male*		Female*		Male*		Female*	
	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
Taylor, 2010	-	29.9	-	29.9													-	24.9	-	24.9
Snehalatha, 2003					-	22.9	-	22.9												
Hadaegh, 2006									-	-										
Hadaegh, 2009											-	30.5								
Thomas, 2004													-	22.1	-	22.1				
Total Range	-	29.9	-	29.9	-	22.9	-	22.9	-	-	-	30.5	-	22.1	-	22.1	-	24.9	-	24.9
Applicable Range	**-**	**29.9**	**-**	**29.9**					**-**	**-**	**-**	**30.5**	**-**	**22.1**	**-**	**22.1**	**-**	**24.9**	**-**	**24.9**

Question 2 WC	Healthy WC Range (cm)																			
	Black				South Asian				Middle Eastern				Chinese				White			
	Male*		Female*		Male		Female		Male		Female		Male*		Female*		Male*		Female*	
	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
Taylor, 2010																				
Snehalatha, 2003					-	84.9	-	79.9												
Hadaegh, 2006									-	-										
Hadaegh, 2009											-	86.9								
Thomas, 2004													-	73.1	-	73.1				
Total Range					-	84.9	-	79.9	-	-	-	86.9	-	73.1	-	73.1				
Applicable Range					**-**	**-**	**-**	**-**	**-**	**-**	**-**	**86.6**	**-**	**73.1**	**-**	**73.1**				

* Data analysis not stratified by sex; combined cut-offs presented for both sexes.

4.3 Question 3:

What are the BMI and waist circumference cut-off points that indicate an increased risk of type 2 diabetes, fatal/non-fatal myocardial infarction and stroke and the need for preventative action among adults from different black, Asian and other minority ethnic groups living in the UK?

Data was extracted for cohort or cross sectional studies which:

- Utilised ROC analysis for BMI and/or WC in black, Asian and minority ethnic populations
  - Provided corresponding sensitivies across a range of BMI or WC values, or
  - Reported an optimised BMI or WC cut-off, calculated using ROC analysis; see Appendix 4 for information regarding optimisation methods used for each study.

4.3.1 People of black descent

One review (Qiao, 2010 [+/+]),[11] one cohort study (Sargeant, 2002 [+/-])[3] and one cross sectional study (Diaz, 2007 [+/+])[12] identified optimal cut-off values amongst black populations using ROC analysis. One study was conducted in the USA, one in the UK and USA, and one in Jamaica. All three studies identified BMI and WC cut-points, and all assessed diabetes as the outcome.

Qiao, 2010.[11] An unreported number of black participants from the USA (from a total sample of 12,814) were included in ROC analysis, used to identify the optimised BMI cut-point for the discrimination of incident diabetes. This study indicates that appropriate BMI cut-off values for the prediction of incident diabetes are the same for black and white men (black men 28 kg/m^2 [sensitivity 61%, specificity 68%] vs. white European men 28 kg/m^2 [sensitivity 64%, specificity 64%]). WC cut-off values were lower among black men (black men 99 cm [Sn 61%, Sp 67%] vs. white European men 103 cm [Sn 65%, Sp 64%]). Black women had higher optimal BMI and WC cut-points compared to white women (BMI: black women 30 kg/m^2 [Sn 63%, Sp 60%] vs. white European women 27.8 kg/m^2 [Sn 68%, Sp 68%]; WC: black women 101 cm [Sn 62%, Sp 68%] vs. white European women 94 cm [Sn 68%, Sp 67%]).

This review has moderate applicability to the UK. It included black participants from a Western country, however, no mean baseline BMI and WC data is provided, and insufficient information is provided the outcome measurements to determine whether or not diabetes diagnosis aligns with current UK practice.

Sargeant, 2002.[3] 728 participants of African ancestry (mean baseline BMI 23.5 males kg/m^2, 27.7 females kg/m^2; mean follow-up 4 years) had an optimised BMI cut-point (AUC) for the prediction of incident diabetes of 24.8 kg/m^2 (0.74) in males and 29.3 kg/m^2 (0.62) in females. WC cut-points (AUC) were 88 cm (0.78) for males and 84.5 cm (0.61) in females.

This study has weak applicability to the UK. Male participants had lower mean BMI than similar ethnic groups in the UK (female measures were similar), and the study included self-reported diabetes diagnosis as a criterion for assessing incident diabetes, which may misclassify cases compared to current UK clinical practice, although the direction of such potential misclassification is unknown.

Diaz, 2007.[12] 486 participants in the English black and 793 participants in the US black subgroups (mean baseline BMI 28.5 (UK) and 29.7 kg/m^2 (US), with a prevalence of diabetes in English blacks 7.5% and in US Blacks 6.6%). It found an optimised BMI cut-point (and associated AUC) for the discrimination of prevalent diabetes in the English black group of 28.7 kg/m^2 (0.59) and in the US black group of 31.7 kg/m^2 (0.60) in men. Among English black women the optimised BMI cutpoint was and 28.1 (0.59) and among US black women the cutpoint was 27.7 kg/m^2 (0.61) in women. This compares to a male cut-point of 28.2 kg/m^2 (0.67) and a female cut-point of 26.7 kg/m^2 (0.66) amongst 6,260 English white participants. Optimised WC cut-points were 100.2 cm (0.67) for English black males compared to 103.4 cm (0.68) for English white males. WC cut-points amongst females were 88.0 cm (0.68) for English black and 91.4 cm (0.72) for English white participants.

This study has moderate applicability to the UK. It included both UK and other Western populations (US), but defined diabetes in a manner that does not align with current UK practice, which may have lead to an overestimation of diabetes cases.

In studies with at least moderate applicability to the UK, a BMI of approximately 28 to 30 kg/m^2 was identified range of BMI identified as optimal for detecting diabetes among a black population. This is slightly higher than the 26 to 28 kg/m^2 identified as optimal for white populations. See Tables 12 and 13 for a summary of results for Question 3.

Evidence statement Q3.1: Optimal BMI cut-points for black populations (Type 2 Diabetes) to indicate need for preventative action

Q3.1.a: UK or Western Countries

Moderate evidence was found from one review (Qiao, 2010 [+/+])[11] and one cross-sectional study (Diaz 2007 [+/+])[12] indicating that the optimal BMI cut-point for the identification of prevalent diabetes in black populations is approximately 28 kg/m^2 for males and 28 to 30 kg/m^2 for females. Optimal values in English white populations were 28.2 kg/m^2 for males and 26.7 kg/m^2 for females.

These studies have moderate applicability to the UK.

Q3.1.b: Other Countries

Moderate evidence was found from one cohort study (Sargeant, 2002 [+/-])[3] that the optimal BMI cut-point for the prediction of incident diabetes amongst black populations in non-Western settings is 24.8 kg/m^2 for males and 29.3 kg/m^2 for females.

This study has weak applicability to the UK.

Evidence statement Q3.2: Optimal WC cut-points for black populations (Type 2 Diabetes) to indicate need for preventative action

Q3.2.a: UK or Western Countries

Moderate evidence was found from one review (Qiao, 2010 [+/+])[11] and one cross-sectional study (Diaz 2007 [+/+])[12] indicating that the optimal WC cut-point for the identification of prevalent diabetes in black populations ranges from 99 to 100.2 cm for males and 88.0 to 101 cm for females. This was compared to optimal values in English white populations of 103.4 cm for males and 91.4 cm for females.

These studies had moderate applicability to the UK.

Q3.2.b: Other Countries

Moderate evidence was found from one cohort study (Sargeant, 2002 [+/-]) that the optimal WC cut-point for the prediction of incident diabetes amongst black populations in non-Western settings is 88 cm for males and 84.5 cm for females.

This study has weak applicability to the UK.

No evidence – Black populations

Evidence statement Q3.3: Optimal BMI cut-points for black populations (myocardial infarction, stroke, mortality) to indicate need for preventative action
No evidence was found relevant to optimal BMI cut-points for myocardial infarction, stroke or mortality in black populations.

Evidence statement Q3.4: Optimal WC cut-points for black populations (myocardial infarction, stroke, mortality) to indicate need for preventative action
No evidence was found relevant to optimal WC cut-points for myocardial infarction, stroke or mortality in black populations.

4.3.2 People of South Asian descent

Two reviews (Nyamdorj, 2010 [+/+])[13] and (Qiao, 2010 [+/+])[11] and six cross sectional studies (Diaz, 2007 [+/+]),[12] (Jafar, 2006 [+/-]),[15] (Mohan, 2007 [+/-]),[14] (Shah, 2009 [-/-]),[55] (Snehalatha, 2003 [-/-])[9] and (Zaher, 2009 [-/-])[56] identified optimal cut-off values for the prediction or discrimination of diabetes amongst South Asian populations. One review included South Asian populations from the UK and the USA, one review included participants from various European and non-Western countries, and the remaining six studies were conducted in India, Pakistan, Nepal and Malaysia. Eight studies identified BMI cut-points, and seven identified WC cut-points.

Nyamdorj, 2010.[13] An unreported number of Indian participants (of 56,038 participants total) had a range of mean BMI from 22.0 to 23.3 kg/m^2 (range of BMI amongst European participants 25.5 to 27.9 kg/m^2). Participants were from various European and non-Western countries. ROC analysis resulted in a lower optimised BMI cut-off value amongst Indian males (22.5 kg/m^2) compared to European males (27.0 kg/m^2). Indian females also had a lower optimal BMI cut-off value (23.1 kg/m^2) compared to European females (28.2 kg/m^2). The optimised WC cut-off value was 85 cm for Indian males compared to 98 cm for European males; and 82 cm for Indian females compared to 86 cm for European females.

This review has moderate applicability to the UK, recruiting participants from various countries, and defining diabetes in a manner consistent with UK clinical practice. Mean baseline BMI among Indian participants was, however, lower than that seen in the Indian population in the UK.

Qiao, 2010.[11] An unreported number of Indian male participants in the UK and the US had optimised WC cutoffs of 97cm, while Indian females in these countries had an optimised WC of 89 cm. The figures for Banladeshi participants were 96 cm for males and 88 cm for females. For Pakistani participants WC cutoffs were 93 cm for males and 101 cm for females. The optimised WC value for white males in the US and UK was 101.6 cm and for white females in the US and UK was 95 cm

This review has moderate applicability to the UK. It included Indian participants from the USA and UK, and diabetes diagnosis aligns with current UK practice. Mean baseline BMI and WC values were not reported, however.

Diaz, 2007.[12] 983 participants in the South Asian subgroups (Indian 535, Pakistani 296, Bangladeshi 152; with mean baseline BMI 26.0, 27.6, and 26.4 kg/m^2 respectively) were assessed for optimised BMI and WC cut-points for the discrimination of prevalent diabetes. BMI cut-off values in South Asian males ranged from 24.2 to 26.5 kg/m^2 (AUC 0.57 to 0.67), which is lower than the identified cut-point of 28.2 kg/m^2 (AUC 0.67) amongst white English males. The identified cut-points for South Asian females ranged from 25.0 to 30.0

kg/m^2 (AUC 0.60 to 0.73); the cut-point amongst white English females was 26.7 kg/m^2 (AUC 0.66). WC cut-points followed a similar pattern with lower values amongst South Asian males (92.5 to 97.2 cm, AUC 0.51 to 0.73) than white English males (103.4 cm, AUC 0.68), and a range of 87.5 to 101.3 cm (AUC 0.65 to 0.83) among South Asian females, compared to 91.4 cm (AUC 0.72) among white English females.

This study had moderate applicability to the UK. It included both UK and other Western populations (US), but defined diabetes in a manner that does not align with current UK practice.

Shah, 2009.[55] 100 participants in Nepal (mean baseline BMI 23.4 kg/m^2, mean baseline WC 82.5 cm) had optimised BMI cut-points (associated sensitivity, specificity and AUC) for the discrimination of prevalent diabetes of 23.6 kg/m^2 (63.2%, 73.3%, 0.69) amongst males and 21.4 kg/m^2 (74.1%, 50.0%, 0.55) amongst females. The optimised WC cut-points in this study were 87 cm (68.4%, 83.3%, 0.87) for males and 85 cm (59.3%, 80.0%, 0.70) for females.

This study has weak applicability to the UK. It included a small number of participants, drawn from a non-Western population, and was conducted in a clinical setting. Mean baseline BMI and WC were lower than values seen in other South Asian populations in the UK. Diabetes was, however, defined in a manner consistent with current UK clinical practice.

Mohan, 2002.[14] 2,600 participants in India (mean baseline BMI 22.6 kg/m^2 for males and 23.1 kg/m^2 for females; mean baseline WC 85.4 cm for males and 81.7 cm for females) had optimised BMI cut-off values (associated sensitivity, specificity and AUC) of 22 kg/m^2 (77.7%, 47.7%, 0.64) amongst males and 23 kg/m^2 (72.0%, 53.6%, 0.65) amongst females. Participants had optimised WC cut-points of 87 cm (68.7%, 58.0%, 0.67) amongst males and 83 cm (64.6%, 60.1%, 0.67) amongst females. Sensitivities were calculated across the range of BMI and WC. Similar sensitivities (range from 85% to 90%) were seen at a BMI of 21 kg/m^2 for both sexes, and WC of 82 cm amongst males and 77 cm amongst females. These may represent appropriate BMI and WC values for health promotion messages in this population. See Appendix 4 for the full range of sensitivities and specificities across all BMI and WC values in the Mohan, 2007 study.

This study had weak applicability to the UK. It was conducted in a non-Western setting, and was comprised of participants with low baseline BMI and WC compared to Indian populations within the UK. Additionally, diabetes was assessed in part by self-report, which may misclassify diabetes case status compared to UK clinical practice, although the direction of this potential misclassification cannot be determined.

Snehalatha, 2003.[9] 10,025 participants in India (mean baseline BMI 22.4 kg/m^2 male and 23.6 kg/m^2 female; mean baseline WC 80.7 cm male and 79 cm female) had optimised BMI cut-points (sensitivity, specificity) for the discrimination of prevalent diabetes of 23 kg/m^2 (67.1%, 62.7%) amongst males and 23 kg/m^2 (66.8%, 52.9%) amongst females. The optimised WC cut-point for males was 85 cm (63.7%, 67.1%) and 80 cm (69.7&%, 56.4%) for females.

This study has weak applicability to the UK. It was conducted in a non-Western setting, participants had low mean baseline BMI and WC compared to Indian populations in the UK and diabetes was assessed in a manner that does not align with current UK clinical practice.

Zaher, 2009.[56] 326 Indians in Malaysia (mean baseline BMI and WC not reported) had optimised BMI cut-points (sensitivity, specificity, AUC) for the discrimination of prevalent diabetes of 22.6 kg/m^2 (90.5%, 28.1%, 0.55) amongst males and 31.2 kg/m^2 (83.3%, 26.7%, 0.50) amongst females. However, the 95% CIs for the ROC AUC corresponding to these cut-points included 0.50, indicating that in this population, BMI performs no better than chance at discriminating diabetes status. The participants had optimised WC cut-points of 84.0 cm (92.9%, 34.4%, 0.64) amongst males and 86.0 cm (75.0%, 44.2%, 0.56) amongst females. The 95% CI for the female ROC AUC included 0.50, indicating that WC does not perform any better than chance in the discrimination of prevalent diabetes.

This study has weak applicability to the UK. It was conducted in a clinical non-Western setting, and did not report mean baseline BMI or diabetes case ascertainment methods.

Jafar, 2006.[15] 8,972 participants from Pakistan (mean baseline BMI not reported) had an optimised BMI cut-point (sensitivity, specificity, AUC) for the discrimination of prevalent diabetes of 22.1 kg/m^2 (56%, 72%, 0.64) amongst males and 22.9 kg/m^2 (59%, 72%, 0.66) amongst females.

This study has weak applicability to the UK. It was conducted in a non-Western setting, and assessed diabetes using outdated criteria that do not align with current UK clinical practice.

In studies with at least moderate applicability to the UK, South Asian men had lower optimal BMI and WC ranges for the detection of diabetes than white males. Comparisons between South Asian and white females are difficult to make as the range of optimal values for both ethnicities were wide. See Tables 12 and 13 for a summary of results for Question 3.

Evidence statement Q3.5: Optimal BMI cut-points for South Asian populations (Type 2 Diabetes) to indicate need for preventative action

Q3.5.a: UK or Western Countries

Moderate evidence was found from one cross-sectional study (Diaz 2007 [+/+])[12] indicating that the optimal BMI cut-point for the identification of diabetes in South Asian populations ranges from 24.2 to 26.5 kg/m^2 for males and 25.0 to 30.0 kg/m^2 for females. Optimal values in white English populations were 28.2 kg/m^2 and 26.7 kg/m^2 for females.

This study has moderate applicability to the UK.

Q3.5.b: Other Countries

Moderate evidence from one review (Nyamdorj, 2010 [+/+])[13] and two cross-sectional studies (Mohan, 2007 [+/-])[14] and (Jafar, 2006 [+/-])[15] indicates that the optimal BMI cut-points for the identification of diabetes in South Asian populations is approximately 22 to 23 kg/m^2 for males and 21 to 23 kg/m^2 for females, and that a BMI as low as 21 kg/m^2 may be appropriate for health promotion messages

These studies had weak to moderate applicability to the UK.

Evidence statement Q3.6: Optimal WC cut-points for South Asian populations (Type 2 Diabetes) to indicate need for preventative action

Q3.6.a: UK or Western Countries

Moderate evidence was found from one review (Qiao, 2010 [+/+])[11] and one cross-sectional study (Diaz 2007 [+/+])[12] indicating that the optimal WC cut-point for the identification of diabetes in South Asian populations ranges from 92.5 to 97.2 cm for males and 87.5 to 101.3 cm for females.

This study had moderate applicability to the UK

Q3.6.b: Other Countries

Moderate evidence from one review (Nyamdorj, 2010 [+/+])[13] and one cross-sectional study (Mohan, 2007 [+/-])[14] indicates that the optimal WC cut-points for the identification of diabetes in South Asian populations ranges from 85 to 87 cm for males and 82 to 83 cm for females.

These studies had weak to moderate applicability to the UK.

No evidence – South Asian populations

Evidence statement Q3.7: Optimal BMI cut-points for South Asian populations (myocardial infarction, stroke or mortality) to indicate need for preventative action

No evidence was found relevant to optimal BMI cut-points for myocardial infarction, stroke or mortality in South Asian populations.

Evidence statement Q3.8: Optimal WC cut-points for South Asian populations (myocardial infarction, stroke or mortality) to indicate need for preventative action

No evidence was found relevant to optimal WC cut-points for myocardial infarction, stroke or mortality in South Asian populations.

4.3.3 People of Middle Eastern descent

One cohort study (Mansour, 2007 [++/+])[4] and four cross sectional studies (Almajwal, 2009 [-/-]),[57] (Mansour, 2007b [+/+]),[17] (Mirmiran, 2004 [++/+])[16] and (Sarrafzadegan, 2010 [+/-])[18] have examined optimal cut-off values for the discrimination of prevalent diabetes amongst Middle Eastern populations in Saudi Arabia, Iraq and Iran. Four studies assessed BMI, and three included WC.

Mansour, 2007.[4] 13,730 participants in Iraq (mean baseline BMI 26.20 kg/m^2; mean baseline WC 91.0 cm; mean follow-up 5 years) had an optimised BMI (AUC) for the prediction of diabetes of 24.7 kg/m^2 (0.66) amongst males and 26.3 kg/m^2 (0.61) amongst females. The optimal WC (AUC) was identified as 90.5 cm (0.71) for males and 92.5 cm (0.69) for females.

This study had moderate applicability to UK. It was conducted in a non-Western setting, however, diabetes diagnostic criteria align with current UK clinical practice, and mean baseline BMIs and WCs were similar to the means seen in the UK general population.

Almajwal, 2009.[57] 195,851 participants in Saudi Arabia (mean BMI 29.69) had optimised BMI cut-points (sensitivity, specificity, AUC) for the discrimination of prevalent diabetes of 28.5 kg/m^2 (55%, 54%, 0.566) amongst males and 31.5 kg/m^2 (58%, 61%, 0.618) amongst females.

This study has weak applicability to the UK. It was conducted in a non-Western setting, participants had higher mean baseline BMI than the UK general population and the study used a diagnostic method that does not align with current UK clinical practice.

Mansour, 2007b.[17] 12,986 participants from Iraq (mean BMI 26.5 kg/m^2, mean WC 91.7 cm) had optimised BMI cut-points (sensitivity, specificity, AUC) for the discrimination of prevalent diabetes of 25.4 kg/m^2 (66.0%, 53.9%, 0.63) amongst males and 26.1 kg/m^2 (66.3%, 47.4%, 0.59) amongst females. Optimised WC cut-points (sensitivity, specificity, AUC) were 90 cm (79.5%, 49.4%, 0.69) amongst males and 91 cm (79.6%, 47.2%, 0.67) amongst females.

This study has moderate applicability to UK. It was conducted in a non-Western setting; however, diabetes diagnostic criteria align with current UK clinical practice, although the methods used to indentify patients with a history of diabetes were not reported. Mean baseline BMIs and WCs were similar to the means seen in the UK general population.

Mirmiran, 2004.[16] 10,522 participants in Iran (mean BMI and WC not reported), stratified by age and sex, had optimised BMI cut-points (AUC) ranging from 25 to 27 kg/m^2 (0.55 to 0.72) for males, and 25.5 to 29 kg/m^2 (0.49 to 0.60) for females. The ability of BMI to discriminate diabetes status in the oldest age cohort (55 to 74 years) was not better than chance, with ROC AUC 95% CIs including 0.50. The optimised WC cut-points (AUC) ranged from 86 to 92 cm (0.56 to 0.69) for males, and 82 to 95 cm (0.55 to 0.67) for females. WC performed no better than chance at the discrimination of diabetes in 18 to 34 year old females.

This study has moderate applicability to UK. It was conducted in a non-Western setting and diabetes diagnostic criteria align with current UK clinical practice; however, mean baseline BMI and WC were not reported.

Sarrafzadegan, 2010.[18] 12,514 participants in Iran (baseline BMI 24.5 kg/m^2 male, 26.7 kg/m^2 female; baseline WC 88.4 cm male, 92.6 cm female) had optimised BMI cut-points (sensitivity, specificity, ROC AUC) of 21.2 kg/m^2 (90%, 70%, 0.68) amongst males and 23.1 kg/m^2 (90%, 72%, 0.65) amongst females. Optimised WC cut-points (sensitivity, specificity, ROC AUC) were 80.7 cm (90%, 70%, 0.73) amongst males and 84.7 cm (90%, 70%, 0.69) amongst females.

This study has weak applicability to UK. It was conducted in a non-Western setting. Male participants had a similar baseline BMI as the UK general population, but mean values of WC among males and BMI and WC among females were dissimilar to the UK general population. The method of diabetes case ascertainment was not reported.

In studies with at least moderate applicability to the UK, Middle Eastern men had optimal BMI and WC ranges for the detection of diabetes of 24.7 to 27 kg/m^2 and 86 to 92 cm. Optimal BMI and WC cut-points for women ranged from 25.5 to 29 kg/m^2 and 82 to 95 cm. See Tables 12 and 13 for a summary of results for Question 3.

Evidence statement Q3.9: Optimal BMI cut-points for Middle Eastern populations (Type 2 Diabetes) to indicate need for preventative action

Q3.9.a: UK or Western Countries

No evidence was found reporting optimal BMI cut-points for the detection or prediction of diabetes among Middle Eastern populations in the UK or other Western Countries.

Q3.9.b: Other Countries

Moderate to strong evidence from one cohort study (Mansour, 2007 [++/+])[4] and three cross-sectional studies (Mirmiran, 2004 [++/+]),[16] (Mansour, 2007b [+/+])[17] and (Sarrafzadegan, 2010 [+/-])[18] indicates that the optimal cut-off value for the identification of prevalent diabetes among Middle Eastern populations living in non-Western countries ranges from 21.2 to 27 kg/m^2 for males and 23.1 to 29 kg/m^2 for females.

These studies have weak to moderate applicability to the UK.

Evidence statement Q3.10: Optimal WC cut-points for Middle Eastern populations (Type 2 Diabetes) to indicate need for preventative action

Q3.10.a: UK or Western Countries

No evidence was found reporting optimal WC cut-points for the identification of prevalent diabetes among Middle Eastern populations in the UK or other Western Countries.

Q3.10.b: Other Countries

Moderate to strong evidence from one cohort study (Mansour, 2007 [++/+])[4] and three cross-sectional studies (Mirmiran, 2004 [++/+]),[16] (Mansour, 2007b [+/+])[17] and (Sarrafzadegan, 2010 [+/-])[18] indicates that the optimal cut-off value for the identification of prevalent diabetes among Middle Eastern populations living in non-Western countries ranges from 80.7 to 92 cm for males and 84.7 to 95 cm for females.

These studies had weak to moderate applicability to the UK.

No evidence – Middle Eastern populations

Evidence statement Q3.11: Optimal BMI cut-points for Middle Eastern populations (myocardial infarction, stroke or mortality) to indicate need for preventative action

No evidence was found relevant to optimal BMI cut-points for myocardial infarction, stroke or mortality in Middle Eastern populations.

Evidence statement Q3.12: Optimal WC cut-points for Middle Eastern populations (myocardial infarction, stroke or mortality) to indicate need for preventative action

No evidence was found relevant to optimal WC cut-points for myocardial infarction, stroke or mortality in Middle Eastern populations.

4.3.4 People of Chinese descent

Two reviews (Qiao, 2010 [+/+]),[11] (Nyamdorj, 2010 [+/+]) and four cross sectional studies (Diaz, 2007 [+/+]),[12] (Ho, 2003 [-/-]),[20] (Ko, 1999 [+/-])[19] and (Zaher, 2009 [-/-])[56] have examined optimal cut-off values for the discrimination of prevalent diabetes among Chinese populations. One study was conducted in the UK and USA, and the remaining five were carried out in Hong Kong, China and Malaysia. All six are relevant identified both BMI and WC cut-points using ROC analysis. All have used diabetes as an outcome. One study included previous stroke as an outcome.

Qiao, 2010.[11] 2,032 participants in Hong Kong (mean baseline BMI and WC not reported) had optimised BMI cut-points (sensitivity, specificity) of 23.3

kg/m^2 (89%, 56%) amongst males and 18.4 kg/m^2 (100%, 15%) amongst females. The optimised WC cut-points were 88.2 cm (78%, 67%) for males and 85.3 cm (58%, 55%) for females. Optimised values among white European males were 28.0 kg/m^2 (64%, 64%) for BMI and 103 cm (65%, 64%) for WC. Among white European females these values were 27.8 kg/m^2 (68%, 68%) for BMI and 94 cm (68%, 67%) for WC.

This review had moderate applicability to the UK. It included Chinese participants from Hong Kong, however, insufficient information is provided on the outcome measurements to determine whether or not diabetes diagnosis aligns with current UK practice.

Nyamdorj, 2010. An unreported number of Chinese participants (of 56,038 participants total) from various European and non-Western countries (mean BMI and WC not reported) had lower optimal BMI and WC cut-off values for the prediction of incident diabetes than European participants. Amongst Chinese males, the optimal BMI cut-off was identified as 25.8 kg/m^2, compared to 27.0 kg/m^2 in European males. For Chinese females, the optimal BMI was found to be 25.4 kg/m^2, compared to 28.2 kg/m^2 for European females. The optimised WC cut-off value was 87 cm for Chinese males and 98 cm for European males, while Chinese females had an optimal WC cut-point of 82 cm for Chinese females versus 86 cm European females.

This review has moderate applicability to the UK, recruiting participants from various countries, and defining diabetes in a manner consistent with UK clinical practice. Mean baseline BMI and WC were not reported, and it is unclear how well these values align with mean BMI and WC among Chinese populations in the UK.

Diaz, 2007.[12] 199 Chinese participants (meant BMI 24.0) from the UK and USA had lower optimised BMI and WC cut-points (AUC) for the discrimination of prevalent diabetes than 6,260 white English participants. Amongst Chinese males, the optimal BMI cut-off was identified as 24.6 kg/m^2 (0.72) compared to 28.2 kg/m^2 (0.67) amongst white English males. Chinese females had an optimal BMI cut-point of 24.1 kg/m^2 (0.79) compared to 26.7 kg/m^2 (0.66) amongst white English females. Optimal WC cut-points were identified as 95.1 cm (0.84) for Chinese males vs. 103.4 cm (0.68) for white English males, and 83.7 cm (0.79) for Chinese females vs. 91.4 cm (0.72) for white English females.

This study has moderate applicability to the UK. It included both UK and other Western populations (US), but defined diabetes in a manner that does not align with current UK practice, which likely resulted in diagnoses of more diabetes cases than would be expected using current diagnostic criteria.

Ho, 2003.[20] 2,895 participants in Hong Kong (mean BMI 24.3 kg/m^2 male, 23.9 kg/m^2 female; mean WC 83.1 cm male, 75.3 cm female) had optimised BMI and WC cut-points (sensitivity, specificity, AUC) for the discrimination of prevalent diabetes of 24.4 kg/m^2 (71.3%, 56.4%, 0.67) for males and 23.33 kg/m^2 (81.4%, 52.0%, 0.71) for females. WC cut-points for discrimination of prevalent diabetes was 83.90 cm (76.0%, 58.2%, 0.71) for males and 78.15 cm (74.5%, 68.8%, 0.76) for females.

This study also identified the BMI and WC cut-points for the discrimination of previous stroke, with an optimal BMI value of 22.2 kg/m^2 among males 26.5 kg/m^2 among females. Optimal WC values for the identification of previous stroke were 79.9 cm among males and 82.9 cm among females. However, neither measure performed better than chance for either males or females, with ROC AUC 95% CIs crossing 0.50 in all instances.

This study has weak applicability to the UK. It was conducted in a non-Western setting, diabetes diagnosis methods do not align with current UK clinical practice and self report was used to determine history of stroke.

Ko, 1999.[19] 1,513 participants in Hong Kong (mean BMI 23.3 kg/m^2, mean WC 78.5 cm) had optimised BMI cut-points (sensitivity, specificity) for the discrimination of prevalent diabetes of 24.3 kg/m^2 (66.5%, 66.5%) amongst males and 24.3 kg/m^2 (66.5%, 65.5%) amongst females. The optimised WC cut-points (sensitivity, specificity) were 84.0 cm (67.4%, 67.2%) amongst males and 78.4 cm (70.0%, 70.0%) amongst females.

This study has weak applicability to the UK. It was conducted in a non-Western setting, and diabetes diagnosis methods do not align with current UK clinical practice.

Zaher, 2009.[56] 546 Chinese participants in Malaysia (mean baseline BMI and WC not reported) were assessed for the discriminatory ability of BMI and WC for prevalent diabetes. Optimal BMI values were 25.5 kg/m^2 among males and 24.3 kg/m^2 (74.2%, 54.7%, 0.57) among females. Optimal WC values were found to be 87 cm for males and 77 cm for females. Neither BMI nor WC performed better than chance in discriminating disease status amongst Chinese males, and WC performed no better than chance for females, with ROC AUC 95% confidence intervals including 0.50 for both measures.

This study has weak applicability to the UK. It was conducted in a clinical non-Western setting, and results from individuals attending a primary care clinic in Malaysia may not be generalisable to Chinese populations in the UK. Additionally, the study did not report mean baseline BMI or diabetes case ascertainment methods.

In studies with at least moderate applicability to the UK, Chinese men had lower optimal BMI and WC ranges for the detection of diabetes than white males (BMI: 22.3 to 25.8 kg/m^2 vs. 27 to 28.2 kg/m^2; WC: 87 to 95.1 cm vs. 98 to 103.4 cm). Chinese women also had lower optimal BMI and WC cut-points, with BMI values ranging from 18.4 to 25.4 kg/m^2 compared to 26.7 to 28.2 kg/m^2 in white females, and WC values of 82 to 85.3 cm compared to 86 to 94 cm in white females. See Tables 12 and 13 for a summary of results for Question 3.

Evidence statement Q3.13: Optimal BMI cut-points for Chinese populations (Type 2 Diabetes) to indicate need for preventative action

Q3.13.a: UK or Western Countries

Moderate evidence was found from one cross-sectional study (Diaz 2007 [+/+])[12] indicating that the optimal BMI cut-point for the identification of prevalent diabetes in Chinese populations is 24.6 kg/m^2 for males and 24.1 kg/m^2 for females; this is lower than optimal values in white populations.

This study had moderate applicability to the UK.

Q3.13.b: Other Countries

Moderate evidence was found from two reviews (Nyamdorj, 2010 [+/+])[13] and (Qiao, 2010 [+/+])[11] and one cross-sectional study (Ko, 1999 [+/-])[19] and indicating that the optimal BMI cut-point for the identification of prevalent or incident diabetes in Chinese populations ranges from 23.3 to 25.8 kg/m^2 for males and 18.4 to 25.4 kg/m^2 for females.

These studies had weak to moderate applicability to the UK.

Evidence statement Q3.14: Optimal BMI cut-points for Chinese populations (myocardial infarction, stroke or mortality) to indicate need for preventative action

No evidence was found relevant to optimal BMI cut-points for myocardial infarction, mortality in Chinese populations.

Q3.14.a: UK or Western Countries

No evidence was found reporting optimal BMI cut-points for the identification of previous stroke among Chinese populations living in the UK.

Q3.14.b: Other Countries

Weak evidence was found from one cross-sectional study (Ho, 2003 [-/-])[20] indicating that BMI does not accurately indentify previous stroke in Chinese populations living in Hong Kong.

This study had weak applicability to the UK.

Evidence statement Q3.15: Optimal WC cut-points for Chinese populations (Type 2 Diabetes) to indicate need for preventative action

Q3.15.a: UK or Western Countries

Moderate evidence was found from one cross-sectional study (Diaz 2007 [+/+])[12] indicating that the optimal WC cut-point for the identification of prevalent diabetes in Chinese populations in the UK or other western countries is 95.1 cm for males and 83.7 cm for females. These cut-points were lower than those identified for both white males and females.

These studies had moderate applicability to the UK

Q3.15.b: Other Countries

Moderate evidence was found from two reviews (Nyamdorj, 2010 [+/+])[13] and (Qiao, 2010 [+/+])[11] one cross-sectional study (Ko, 1999 [+/-])[19] indicating that the optimal WC cut-point for the identification of prevalent diabetes in Chinese populations in Hong Kong or other non-Western settings ranges from 84 to 88.2 cm for males and 78.4 to 85.3 cm for females.

These studies had weak to moderate applicability to the UK.

Evidence statement Q3.16: Optimal WC cut-points for Chinese populations (myocardial infarction, stroke or mortality) to indicate need for preventative action

No evidence was found relevant to optimal WC cut-points for myocardial infarction or mortality in Chinese populations.

Q3.16.a: UK or Western Countries

No evidence was found reporting optimal WC cut-points for the identification of stroke among Hong Kong Chinese populations living in the UK.

Q3.16.b: Other Countries

Weak evidence was found from one cross-sectional study (Ho, 2003 [-/-])[20] indicating that WC does not accurately indentify previous stroke in Chinese populations living in Hong Kong.

This study had weak applicability to the UK.

4.3.5 Mixed ethnic populations

Two reviews (Huxley, 2008 [+/+])[21] and (Qiao, 2010 [+/+])[11] evaluated the discriminatory ability of BMI and WC in terms of prevalent diabetes in mixed Asian populations. Both studies included a white or European comparator group.

Huxley, 2008.[21] 201,952 Asian participants and 61,776 white participants (range of mean BMI 21.0 to 27.2 kg/m^2 for males and 21.2 to 27.5 kg/m^2 for females. range of mean WC 78.2 to 97.5 cm for males and 72.0 to 87.5 cm for females) were included in ROC analysis evaluating the optimal of BMI and WC cut-points for the discrimination of prevalent diabetes. Asian males and females had lower optimal BMI and WC cut-points compared to white participants of the same sex. The BMI cut-points were 24 kg/m^2 for Asian males compared to 28 kg/m^2 for white males, and 25 kg/m^2 for Asian females compared to 28 kg/m^2 for white females. The optimised WC cut-points were 85 cm amongst Asian males vs. 99 cm amongst white males, and 80 cm amongst Asian females compared to 85 cm for white females.

This review has moderate applicability to the UK. It included participants mainly from non-Western countries, although a Western country was also included. While diabetes was defined in a manner that aligns with current UK clinical practice and included a white comparator group, the range of baseline BMI and WC include values that are lower than those seen in Chinese and South Asian groups as well as those seen in the general UK population.

Qiao, 2010.[11] 566 Chinese, Indian and Malay female participants in Singapore (mean baseline WC not reported) had an optimised BMI cut-point (sensitivity, specificity) for the prediction of incident diabetes of 23.2 kg/m^2 (96%, 57%) and an optimised WC cut-point of 79.5 cm (89%, 74%). No cut-point for males was reported.

This review had moderate applicability to the UK. It included participants from both Western and non-Western settings, however, insufficient information is provided on the outcome measurements to determine whether or not diabetes diagnosis aligns with current UK practice.

The studies with moderate applicability to the UK found that mixed ethnic populations had optimal BMI and WC cut-points for the detection of diabetes approximately 24 kg/m^2 and 85 cm for men and 23 to 25 kg/m^2 and approximately 80 cm for females. See Tables 12 and 13 for a summary of results for Question 3.

Evidence statement Q3.17: Optimal BMI cut-points for mixed ethnic populations (Type 2 Diabetes) to indicate need for preventative action
Q3.17.a: UK or Western Countries

No evidence was found reporting optimal BMI cut-points for the identification of prevalent diabetes among mixed populations in solely the UK or other Western Countries.

Moderate evidence was found from two reviews (Huxley, 2008 [+/+])[21] and (Qiao, 2010 [+/+])[11] indicating that the optimal BMI cut-point for the identification of prevalent diabetes in mixed ethnic populations is approximately 24 kg/m^2 for males and 23 to 25 kg/m^2 for females.

These studies had weak to moderate applicability to the UK.

Evidence statement Q3.18: Optimal WC cut-points for mixed ethnic populations (Type 2 Diabetes) to indicate need for preventative action
Q3.18.a: UK or Western Countries

No evidence was found reporting optimal WC cut-points for the identification of prevalent diabetes among mixed ethnic populations in solely the UK or other Western countries.

Q3.18.b: Other Countries

Moderate evidence was found from two reviews (Huxley, 2008 [+/+])[21] and (Qiao, 2010 [+/+])[11] indicating that the optimal WC cut-point for the identification of prevalent diabetes in mixed ethnic populations is 85 cm for males and approximately 80 cm for females.

These studies had moderate applicability to the UK.

Table 12: Question 3 results summary, Optimal BMI cut-off values.

Question 3 BMI	**Optimal BMI Cut-off Values (kg/m^2)**											
	Black		South Asian		Middle Eastern		Chinese		Mixed Ethnic		White/European	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Sargeant, 2002	24.8	29.3										
Qiao, 2010	28	30					22.3*	18.4*	-	23.2*	28.0	27.8
Diaz, 2007	28.7	28.1	24.2-26.5	25-30			24.6	24.1			28.2	26.7
Jafar, 2006			22.1	22.9								
Mohan, 2007			22	23								
Mohan, 2007 (Sn >85%)			21*	21*								
Snehalataha, 2003			23	23								
Shah, 2009			23.63	21.40								
Zaher, 2009			22.6*	31.2			25.5	24.3				
Nyamdorj, 2010			22.5	23.1			25.8	25.4			27.0	28.2
Ho, 2003							22.2-24.4*	23.3-26.5				
Ko, 1999							24.3	24.3				
Almajawal, 2009					28.5	31.5						
Mansour, 2007					24.7	26.3						
Mansour, 2007b					25.4	26.1						
Mirmiran, 2003					25-27	25.5-29						
Sarrafzadegan, 2010					21.2*	23.1*						
Huxley, 2010									24	25	28	28
Total Range	24.8-28.7	28.1-30	21-26.5	21-31.2	21.2-28.5	23.1-31.5	22.2-25.8	18.4-26.5	24	23.2-25	27-28.2	26.7-28.2
Cut-offs with Sn>85%	**-**	**-**	**21-22.6**	**21**	**21.2**	**23.1**	**22.2-24.4**	**18.4**	**-**	**23.2**	**-**	**-**
Applicable Range	**28-28.7**	**28.1-30**	**22.5-26.5**	**23.1-30**	**24-7-27**	**25.5-29**	**22.3-25.8**	**18.4-25.4**	**24**	**23.2-25**	**27-28.2**	**26.7-28**

* Optimal cut-off values with sensitivity greater than 85%

Table 13: Question 3 results summary, Optimal WC cut-off values.

Question 3 WC	**Optimal WC Cut-off Values (cm)**											
	Black		South Asian		Middle Eastern		Chinese		Mixed Ethnic		White/European	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Sargeant, 2002	88	84.5										
Qiao, 2010	99	101	93-97	88-101	86-92	82-95	88.2	85.3	-	79.5*	103	94
Diaz, 2007	100.2	88	92.5-97.2	87.5-101.3			95.1	83.7			103.4	91.4
Jafar, 2006												
Mohan, 2007			87	83								
Mohan, 2007 (Sn >85%)			82*	77*								
Snehalataha, 2003			85	80								
Shah, 2009			87	85								
Zaher, 2009			84.0*	86.0			97	77*				
Nyamdorj, 2010			85	82			87	82			98	86
Ho, 2003							79.9-83.9*	78.2-82.9				
Ko, 1999							84.0	78.4				
Almajawal, 2009					-	-						
Mansour, 2007					90.5	92.5						
Mansour, 2007b					90	91						
Mirmiran, 2003					86-92	82-95						
Sarrafzadegan, 2010					80.7*	84.7*						
Huxley, 2010									85	80	99	85
Total Range	88-100.2	84.5-101	82-97.2	77-101.3	80.7-92	82-95	79.9-97	77-82.9	85	79.5-80	98-103.4	85-94
Cut-offs with Sn>85%	**-**	**-**	**82-84.0**	**77**	**80.7**	**84.7**	**79.9-83.9**	**77**	**-**	**79.5**	**-**	**-**
Applicable Range	**99-100.2**	**88-101**	**85-97.2**	**82-101.3**	**86-92**	**82-95**	**87-95.1**	**82-85.3**	**-**	**79.5**	**98-103.4**	**86-94**

* Optimal cut-off values with sensitivity greater than 85%

4.4 Question 4:

What are the cut-off points for BMI and waist circumference among adults from black, Asian and other minority ethnic groups living in the UK that are 'risk equivalent' to the current thresholds set for white European populations?

Data (or graphs) were extracted for cohort or cross sectional studies which:

- Presented graphs with risk curves for incident or prevalent diabetes by BMI or WC (as either a continuous or categorical variable), with separate curves for each ethnicity, with a white comparator group
- Provided data on diabetes prevalence by BMI or WC (as either a continuous or categorical variable), stratified by ethnicity, with a white comparator group
- Reported risk-equivalent BMI or WC values compared to white populations

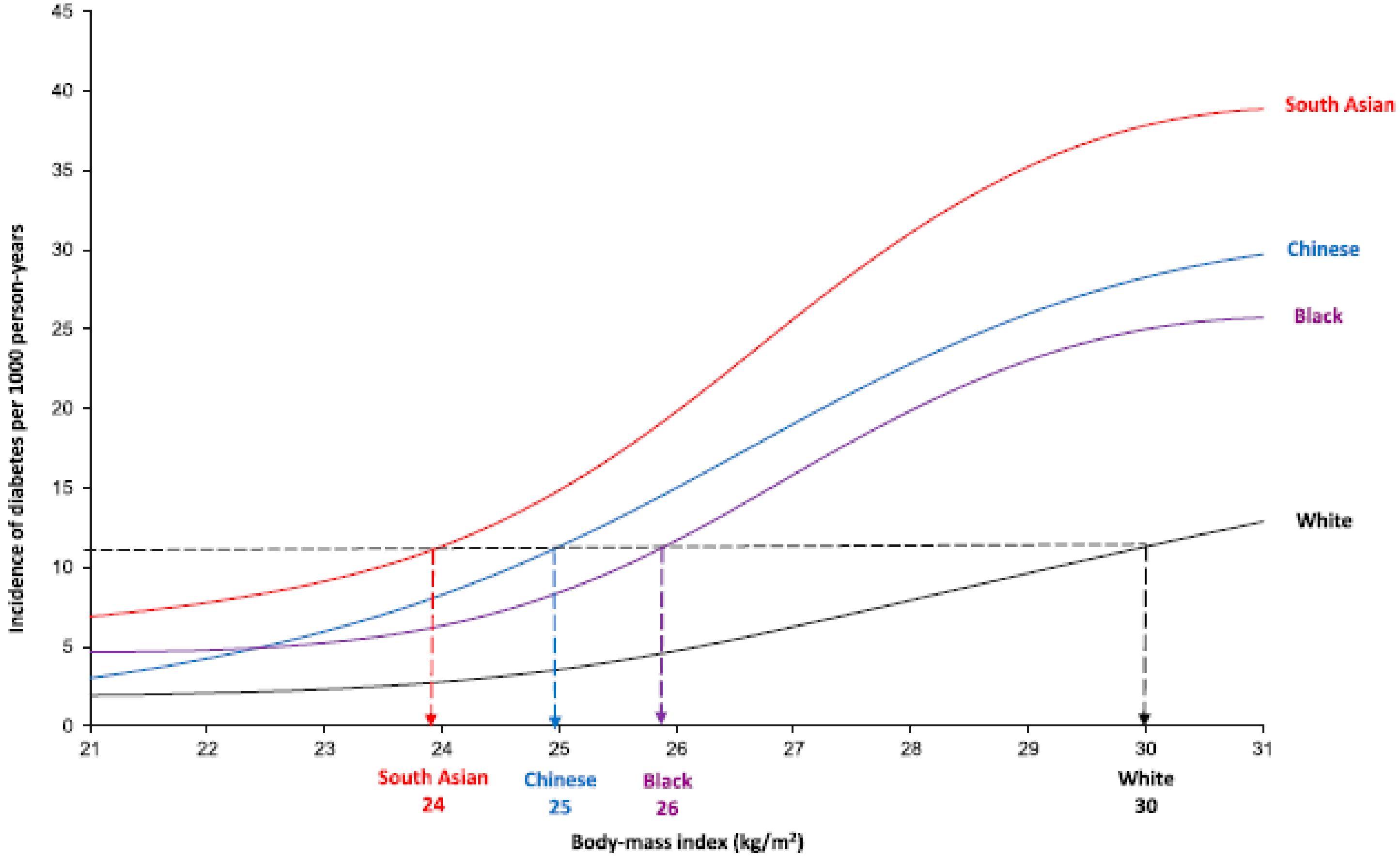
4.4.1 People of black descent

Two cohort studies (Chiu, 2011 [+/+]),[22] (Stevens, 2008 [+/+])[23] and two cross sectional studies (Stommel, 2010 [+/+])[24] and (Taylor, 2010 [++/+])[8] examined equivalency of the boundary cut-points amongst black populations. The studies were conducted in the UK, Canada, and the USA. All of the studies are relevant to BMI cut-points and none looked at WC equivalency. All have used diabetes as an outcome.

Chiu, 2011.[22] 747 participants in the black subgroup (mean baseline BMI 26.1 kg/m^2) had an increased age-adjusted risk of incident diabetes; HR 2.04 (95% CI 1.50 to 2.68) compared to a white subgroup of 57,210 participants. The risk equivalent BMI values (kg/m^2) for European 30 kg/m^2 was calculated as 26 kg/m^2. This difference of -4 kg/m^2 is presented in Figure 8.

This study has moderate applicability to the UK. It was conducted in a Western setting, and mean baseline BMIs were similar to those seen in similar ethnic groups in the UK. However, it included a small black subgroup, and the diagnositic criteria used to identify diabetes cases was not reported.

Figure 8: Association between the incidence rate of diabetes and BMI by ethnic group. Ontario, Canada. 1996–2005

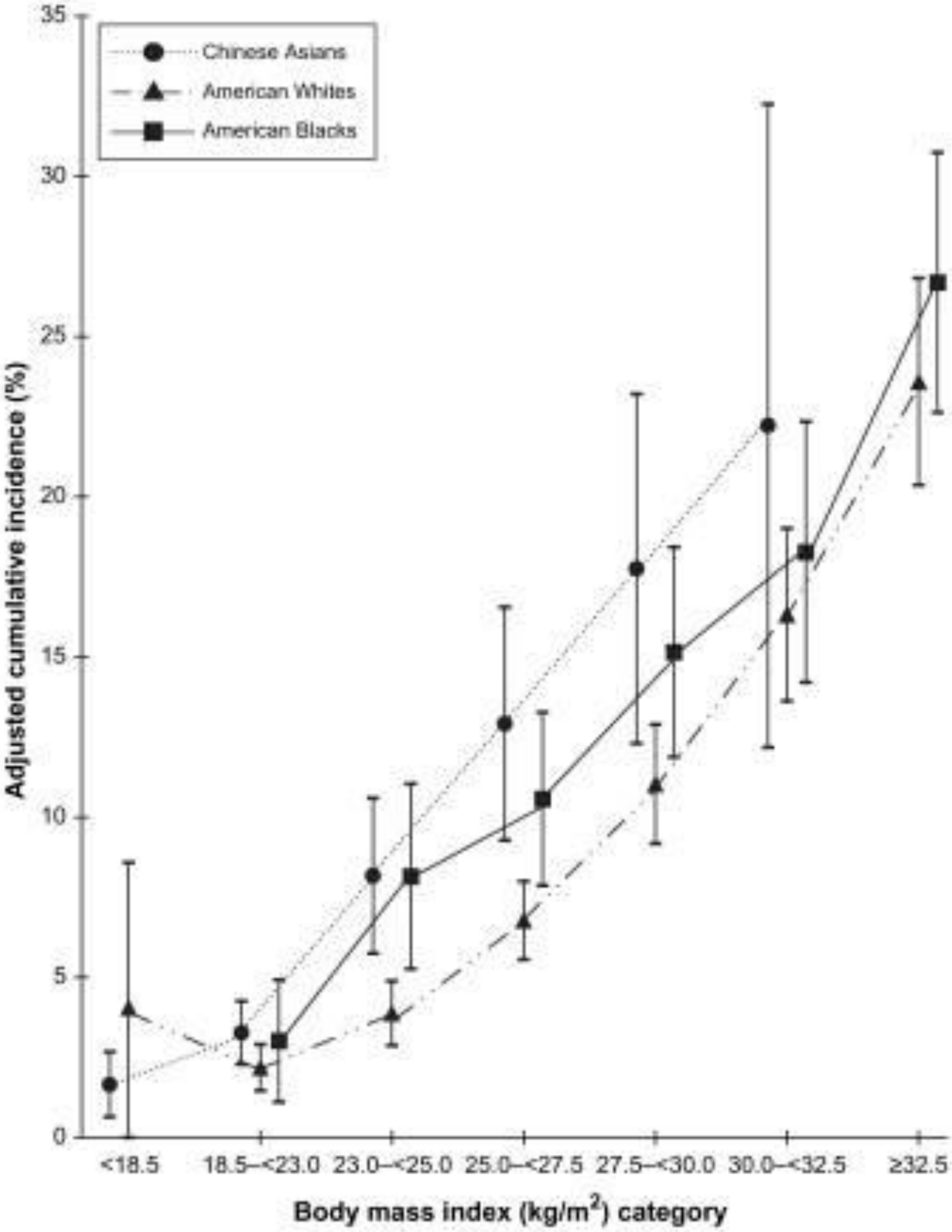


Source: Chiu, 2011.[22] (Fig. 1 in paper)

Stevens 2008. 3,582 participants in the American black subgroup (mean male baseline BMI 27.8 kg/m^2, female 30.8 kg/m^2; mean follow-up 7.9 to 8.2 years) had an increased risk of incident diabetes in higher BMI categories compared to a reference BMI 18.5 to 23 kg/m^2 category. In the 25.0 to 27.49 kg/m^2 category for American whites the risk difference was +4.6% (95% CI -10.1 to 19.3) close to an equivalent risk difference of +5.1% (95% CI -17.3 to +27.6) in the 23.0 to 24.9 kg/m^2 categorty among the American black subgroup. This difference of about -2 kg/m^2 is presented in Figure 9. In the 30.0 to 32.49 kg/m^2 category for American whites the risk difference was +14.1 (95% CI -27.0 to +55.2), close to an equivalent risk of +15.2 (95% CI -29.9 to +60.2) in the 30.0 to 32.49 kg/m^2 category for the American black subgroup.

This study has moderate applicability to the UK. The black and white subpopulations were sampled from the USA. Diabetes diagnosis, however, was based on self-report, which may misclassify cases compared to current UK practice.

Figure 9: Adjusted cumulative incidence of diabetes among Chinese Asians, American whites and American blacks across BMI categories

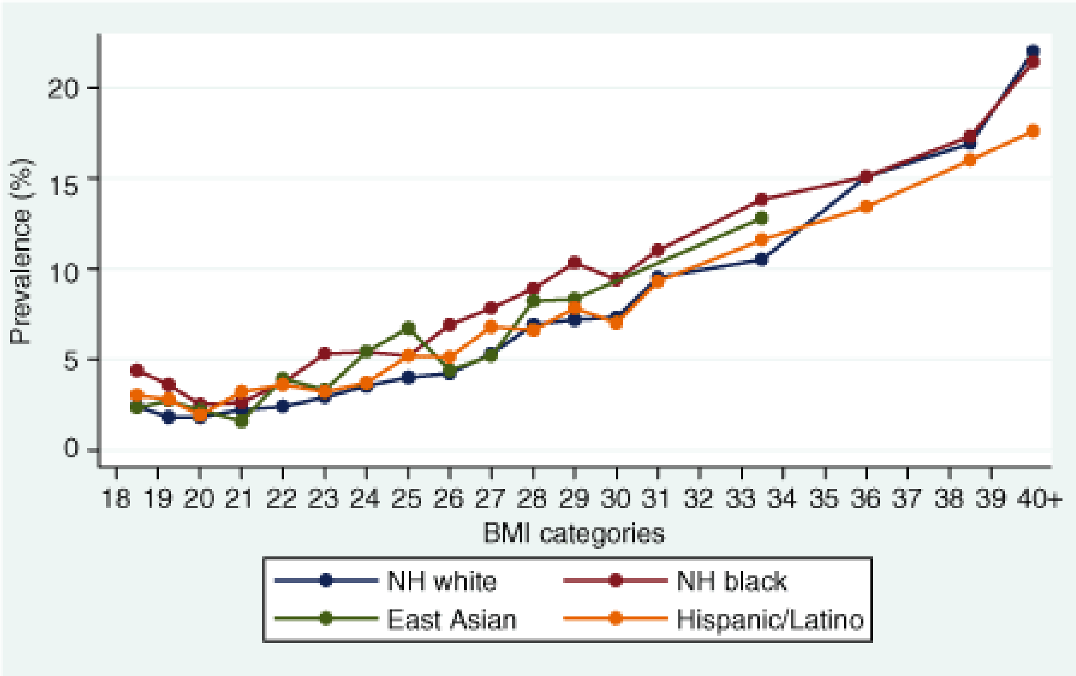


Source: Stevens, 2008.[23] (Fig. 2 in paper)

Stommel, 2010.[24] 47,468 participants in the US black subgroups (mean baseline BMI not reported) self reported their diabetes (9.3% prevalence). The prevalence of diabetes was compared to the prevalence among 219,521 participants in the white subgroup (6.1%). Results are reported by ethnicity or BMI but not both. Visual inspection of the prevalence vs. BMI graph (see Figure 10) suggests that prevalence of diabetes is approximately equivalent at a BMI of 26 kg/m^2 among black participants and 30 kg/m^2 among white participants, a difference of -4 kg/m^2. An equivalent prevalence is seen at approximately 21 to 22 kg/m^2 among black participants and 25 kg/m^2 among white participants, a difference of about -3 to -4 kg/m^2.

This study has moderate applicability to the UK. It was conducted in a Western country, however, BMI and diabetes case status were assessed by self-report, a manner inconsistent with current UK clinical practice.

Figure 10: Prevalence of diabetes by BMI categories in four US populations, adjusted for age, sex, education, poverty, marital status, insurance, residency, foreign birth, health behaviours

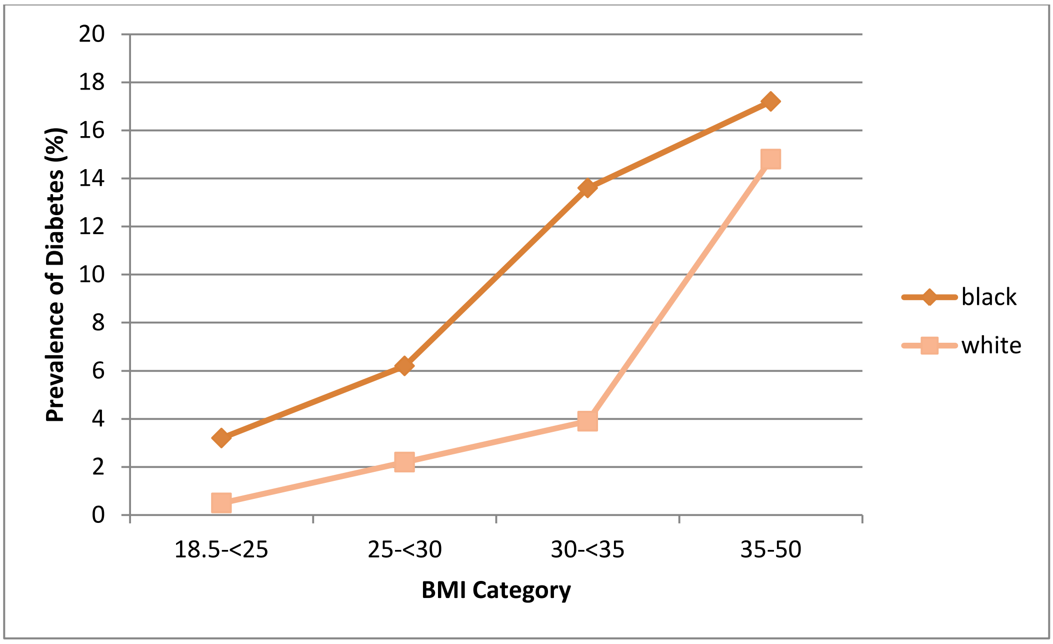


Source: Stommel et al, 2010.[24] (Fig 2 in paper)

Taylor, 2010.[8] 4,030 participants in the US black subgroup (mean baseline BMI not reported) had consistently higher prevalence of diabetes compared to a US white subgroup (n=5,245) at all BMI categories. Figure 11, generated using the published prevalence data for participants aged 35 to 54 years, illustrates the increase diabetes risk across the spectrum of BMI categories, and suggests that black Americans may have a diabetes risk equivalent to that seen above 30 kg/m^2 in white populations in a BMI range as low as 18.5 to 25 kg/m^2. Figure 12, similarly generated from published prevalence data, illustrates a pattern of higher diabetes risk across all BMI categories in black participants aged 55 to 74 years, compared to white participants in the same age cohort. However, as the publication did not provide confidence intervals around the prevalence figures, it is unknown whether the prevalence difference between these two subgroups is significant. Additionally, due to the wide BMI categories used (approximately 5 BMI units per category) it is difficult to interpret these prevalence figures to determine risk equivalency. As such, it has not been included in the results summary tables (Table 14 and 15) for Question 4.

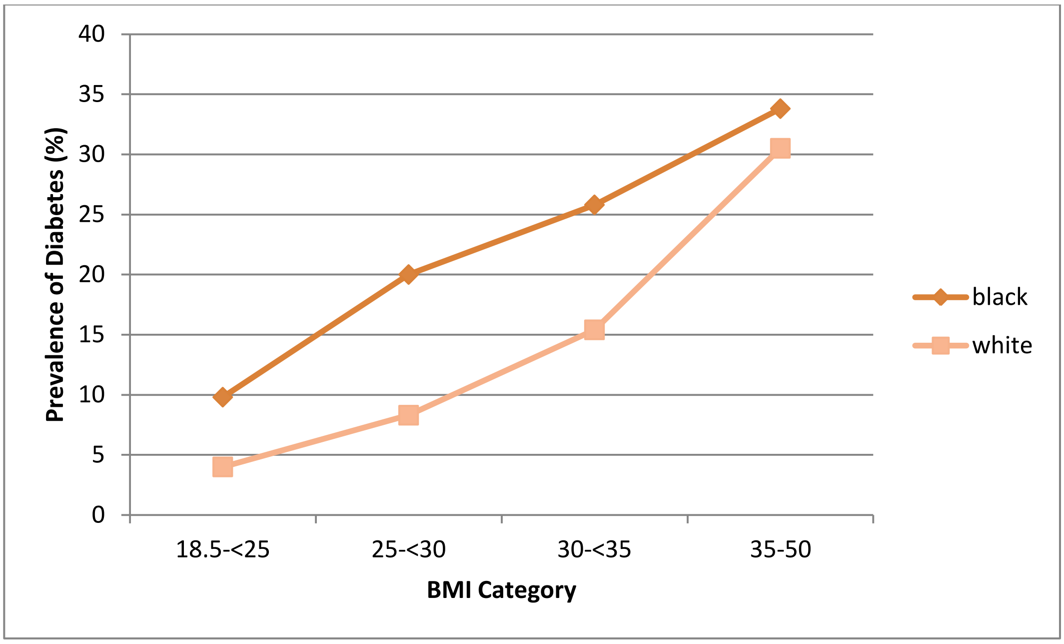
This study has moderate applicability to the UK. It was conducted in a Western country, however, diabetes case status were assessed in part by medication use, which could misclassify cases compared to current UK clinical practice.

Figure 11: Diabetes prevalence by BMI category among black and white participants aged 35 to 54 years



Adapted from: Taylor, 2010.[8]

Figure 12: Diabetes prevalence by BMI category among black and white participants aged 55 to 74 years



Adapted from: Taylor, 2010.[8]

See Tables 14 through 17 for a summary of results for Question 4.

Evidence statement Q4.1: BMI cut-points indicating "risk equivalence" for black populations (Type 2 Diabetes)

Limited evidence suggests that black populations with a BMI of 26 kg/m^2 were found to have the same diabetes risk as white populations with a BMI of 30kg/m^2, and 21 to 23 kg/m^2 appears to be risk equivalent to 25 kg/m^2 in a white population.

Q4.1.a: UK or Western Countries

Moderate evidence was found from two cohorts in Canada and the US and two cross-sectional studies in the US (Chiu, 2011 [+/+]),[22] (Stevens, 2008 [+/+])[23], (Stommel, 2010 [+/+])[24] and (Taylor, 2010 [++/+])[8] that for BMI around 30 kg/m^2 in white populations the equivalent incident diabetes risk in black populations was found at BMI values 4 units lower (26 kg/m^2). For a BMI around 25 kg/m^2 in white populations the equivalent incident diabetes risk in black populations was found at BMI values 2 to 4 units lower 21 to 23 kg/m^2).

These studies had moderate applicability to the UK.

No evidence – Black populations

Evidence statement Q4.2: BMI cut-points indicating "risk equivalence" for black populations (myocardial infarction, stroke or mortality)
No evidence was found relevant to risk equivalent BMI cut-points for myocardial infarction, stroke or mortality in black populations.

Evidence statement Q4.3: WC cut-points indicating "risk equivalence" for black populations (Type 2 Diabetes)

No evidence was found relevant to risk equivalent WC cut-points for diabetes in black populations.

Evidence statement Q4.4: WC cut-points indicating "risk equivalence" for black populations (myocardial infarction, stroke or mortality)
No evidence was found relevant to risk equivalent WC cut-points for myocardial infarction, stroke or mortality in black populations.

4.4.2 People of South Asian descent

One review (Nyamdorj, 2010b [+/++])[25] and one cohort study (Chiu, 2011 [+/+])[22] have examined equivalency of the boundary cut-points amongst South Asian populations. The review included participants from various European and non-Western countries and the cohort study was based in Canada. Both studies are relevant to BMI cut-points and one has looked at WC equivalency. Both have used diabetes as an outcome.

Nyamdorj, 2010b.[25] This review and meta-analysis included 30 studies with 54,467 participants from China, India, Mauritius, Cyprus, Finland, Italy, Spain, Sweden, Netherlands, and the UK. Among Indian participants, the ranges of mean baseline BMIs were 22.0 to 23.3 kg/m^2 for males and 23.7 to 24.5 kg/m^2 for females. Mean baseline BMI ranged from 25.5 to 27.9 kg/m^2 among European males and 25.2 to 28.1 kg/m^2 among European females. Mean baseline WC ranged from 81.2 to 87.7 cm among Indian males and 75.5 to 84.4 cm among Indian females. European female baseline WC ranged from 77.6 to 86.9 cm.

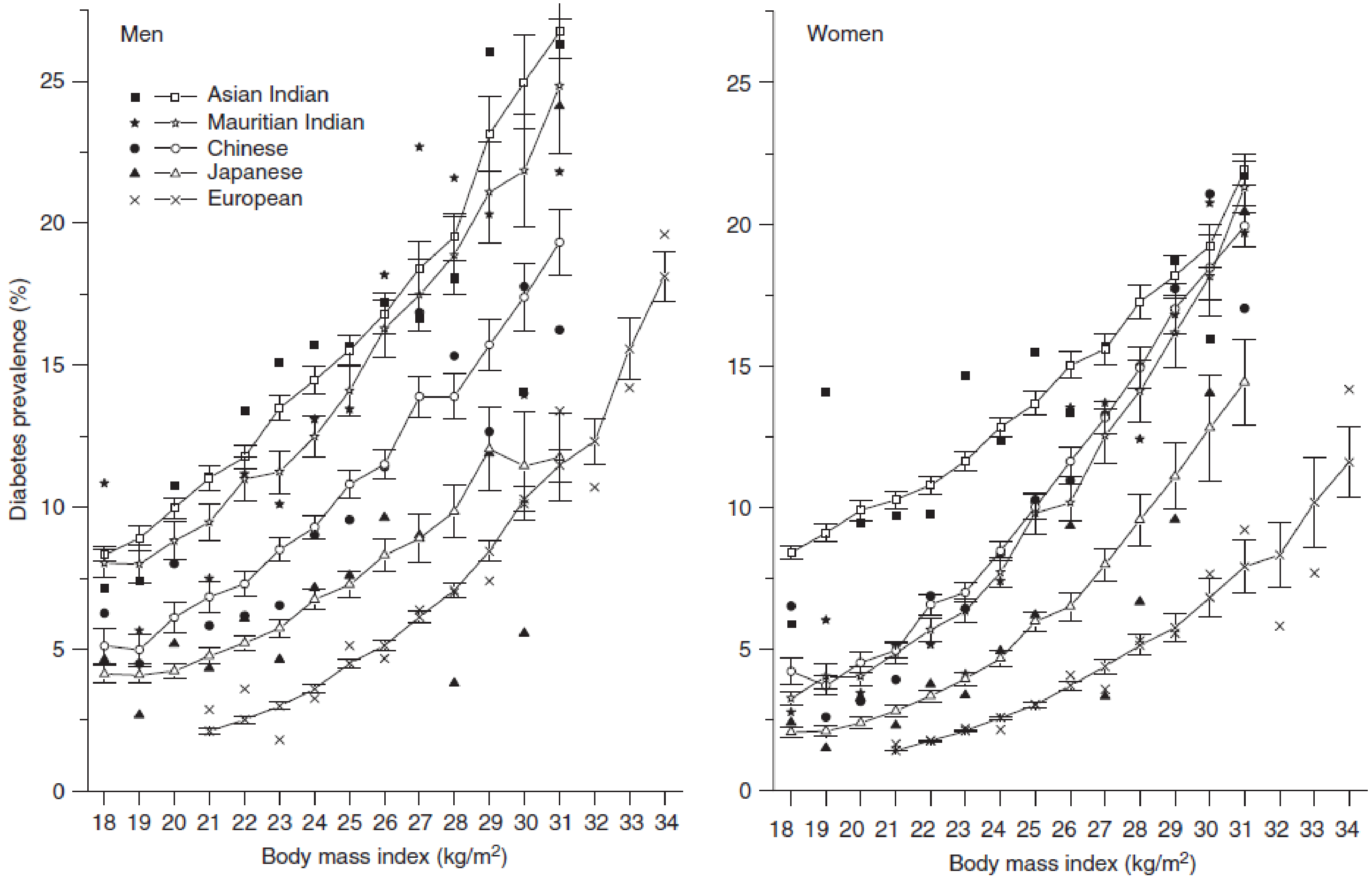
At the same BMI or WC levels, undiagnosed diabetes was more prevalent in Indians than Europeans (see Figures 13 and 14). Visual inspection of Figure 13 suggests that the pooled risk equivalence for undiagnosed diabetes for Europeans at 30 kg/m^2 was present at a BMI of 19 to 20 kg/m^2 for Indian males, a difference of -10 to -11 kg/m^2 for Indian male compared to European males. A risk equivalent point cannot be calculated for females, as the risk curve for Indian women does not include prevalence as low as that seen among European women at 30 kg/m^2. No risk equivalent points can be identified for a European BMI of 25 kg/m^2, as the risk curves for male and female Indian participants do not include prevelance values as low as that seen at this BMI among Europeans.

Visual inspection of the graphs in Figures 14 suggests that the pooled risk equivalence for undiagnosed diabetes for European men at WC of 102 cm is 73 cm for Indian men, a difference of -29 cm. The risk equivalent for a WC 94 cm cannot be calculated as the risk curve for Indian men does not include a prevalence as low as that seen among European men at 94 cm.

The pooled risk equivalent for undiagnosed diabetes for European women at WC of 88 or 80 cm can not be calculated as the risk curve for Indian women does not include prevalences as low as those seen among European women at these thresholds.

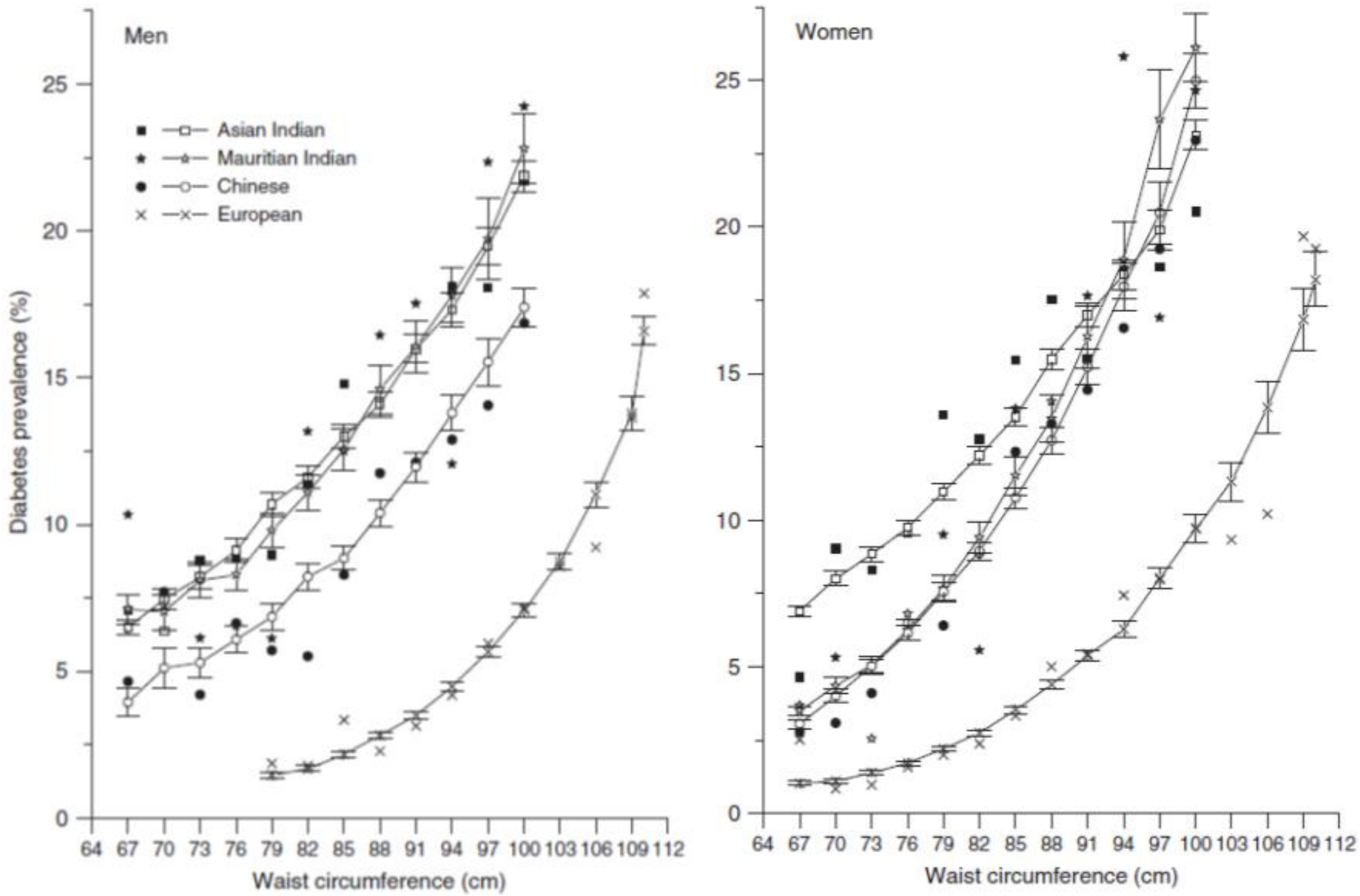
This study has strong applicability to the UK, recruiting participants from various countries including the UK and other Western countries and defining diabetes in a manner consistent with UK clinical practice. Participants mean baseline BMI and WC largely align with the mean values seen in the relevant ethnic minority groups in the UK.

Figure 13: Crude (filled markers) prevalence and estimated (open markers with 95% CIs) probability of undiagnosed diabetes among males according to BMI categories by ethnicity.



Source: Nyamdorj et al, 2010.[25] (fig 1 in paper)

Figure 14: Crude (filled markers) prevalence and estimated (open markers with 95% CIs) probability of undiagnosed diabetes among males and females according to the waist circumference categories by ethnicity.



Source: Nyamdorj et al, 2010.[25] (fig 2 in paper)

Chiu, 2011.[22] 1,001 participants in the South Asian subgroup (mean baseline BMI 24.6 kg/m^2; mean follow-up 6 years) had risk equivalent BMI values for a European BMI of 30 kg/m^2 at 24 kg/m^2. A difference of -6 kg/m^2 is presented graphically in Figure 8.

This study has moderate applicability to the UK. It was conducted in a Western setting, and mean baseline BMIs were similar to those seen in South Asian groups in the UK. However the diagnositic criteria used to identify diabetes cases was not reported.

See Tables 14 through 17 for a summary of results for Question 4.

Evidence statement Q4.5: BMI cut-points indicating "risk equivalence" for South Asian populations (Type 2 Diabetes)

Q4.5.a: UK or Western Countries

Moderate evidence was found from one cohort in Canada (Chiu, 2011 [+/+])[22] that for BMI around 30 kg/m^2 in white populations the equivalent incident diabetes risk in South Asian populations was found at BMI values 6 units lower. No equivalent value to a BMI of 25 kg/m^2 was reported.

This study had moderate applicability to the UK.

Q4.5.b: Other Countries

Moderate graphical evidence was found from one review (Nyamdorj, 2010b [+/++])[25] related to diabetes risk across BMI values, indicating a risk equivalence at 19 to 20 kg/m^2 among South Asian men and 30 kg/m^2 among European men. No risk equivalence points were identified for women at this BMI cutoff, and no values were identified for either men or women equivalent to the risk seen among Europeans at 25 kg/m^2.

This study had strong applicability to the UK.

Evidence statement Q4.6: WC cut-points indicating "risk equivalence" for South Asian populations (Type 2 Diabetes)

Moderate graphical evidence was found from one review (Nyamdorj, 2010b [+/++])[25] that at a WC of 73 cm, Indian men experience the same diabetes risk as European men exhibit at 102 cm. No risk equivalent values were identified for the Europen WC cut-off of 94 cm among men, 88 cm among women or 80 cm among women.

This study had strong applicability to the UK.

No evidence – South Asian populations

Evidence statement Q4.7: BMI cut-points indicating "risk equivalence" for South Asian populations (myocardial infarction, stroke or mortality)
No evidence was found relevant to risk equivalent BMI cut-points for myocardial infarction, stroke or mortality in South Asian populations.

Evidence statement Q4.8: WC cut-points indicating "risk equivalence" for South Asian populations (myocardial infarction, stroke or mortality)
No evidence was found relevant to risk equivalent WC cut-points for myocardial infarction, stroke or mortality in South Asian populations.

4.4.3 People of Middle Eastern descent

No studies were identified that identified risk equivalent BMI or WC points between Middle Eastern and white populations.

Evidence statement Q4.9: BMI cut-points indicating "risk equivalence" for Middle Eastern populations (Type 2 Diabetes)

No evidence was found relevant to risk equivalent BMI cut-points for diabetes Middle Eastern populations.

Evidence statement Q4.10: BMI cut-points indicating "risk equivalence" for Middle Eastern populations (myocardial infarction, stroke or mortality)
No evidence was found relevant to risk equivalent BMI cut-points for myocardial infarction, stroke or mortality in Middle Eastern populations.

Evidence statement Q4.11: WC cut-points indicating "risk equivalence" Middle Eastern populations (Type 2 Diabetes)

No evidence was found relevant to risk equivalent WC cut-points for diabetes in Middle Eastern populations.

Evidence statement Q4.12: WC cut-points indicating "risk equivalence" for Middle Eastern populations (myocardial infarction, stroke or mortality)
No evidence was found relevant to risk equivalent WC cut-points for myocardial infarction, stroke or mortality in Middle Eastern populations..

4.4.4 People of Chinese descent

One review (Nyamdorj, 2010b [+/++])[25] and two cohorts (Chiu, 2011 [+/+]),[22] (Stevens, 2008 [+/+])[23] have examined equivalency of the boundary cut-points amongst Chinese populations. Studies were conducted in Canada, the US, China, and various European and non-Western countries. Three are relevant to BMI cut-points and one has looked at WC equivalency. All have used diabetes as an outcome.

Nyamdorj, 2010b.[25] In this review and meta-analysis of 30 studies, 54,467 participants from China, India, Mauritius, Cyprus, Finland, Italy, Spain, Sweden, Netherlands, UK took part. Mean baseline BMI among Chinese males ranged from 24.3 to 26.6 kg/m^2, and 24.3 to 26.3 kg/m^2 in Chinese females. The range in European participants was 25.5 to 27.9 kg/m^2 among males and 25.2 to 28.1 kg/m^2 among females. Mean baseline WC ranged from 83.5 to 89.9 cm in Chinese males, 76.6 to 83.4 cm in Chinese females, 91.4 to 98.4 cm in European males and 77.6 to 86.9 cm in European females.

At the same BMI or WC levels, undiagnosed diabetes was more prevalent in Chinese participants than Europeans (see Figures 13 and 14). Visual inspection of Figures 13 suggests that the pooled risk equivalence for undiagnosed diabetes for Europeans at 30 kg/m^2 was presented as between 24 and 25 kg/m^2 for Chinese males, a difference of -5 to -6 kg/m^2 compared to European males. Equivalent prevalence was seen at 22 kg/m^2 in Chinese females and 30 kg/m^2 in European females, a difference of -8 kg/m^2. Risk equivalence for a 25 kg/m^2 BMI in Europeans could not be estimateded as the risk curves for Chinese populations do not include prevalences as low as those seen among Europeans at this threshold.

Visual inspection of the graph in Figure 14 suggests that the pooled risk equivalence for undiagnosed diabetes for European men at WC of 102 cm is 82 cm for Chinese men, a -20 cm difference. The risk equivalent for a WC 94 cm in European men is between 67 and 70 cm among Chinese men, a difference of -12 to -15 cm.

Visual inspection of Figure 14 suggests that the pooled risk equivalence for undiagnosed diabetes for European women at WC of 88 cm is between 70 and 73 cm among Chinese women, a difference of -15 to 18 cm. An equivalent point for 80 cm cannot be discerned as the risk curve for Chinese women does not include prevalence as low as those seen among European women at this threshold.

This study has strong applicability to the UK, recruiting participants from various countries including the UK and other Western countries and defining diabetes in a manner consistent with UK clinical practice. Participants mean baseline BMI and WC largely align with the mean values seen in the relevant ethnic minority groups in the UK.

Chiu, 2011.[22] 866 participants in the Chinese subgroup (mean baseline BMI 22.6 kg/m^2; follow-up 6 years) had risk equivalent BMI values for a European BMI of 30 kg/m^2 at 25 kg/m^2. This difference of -5 kg/m^2 is presented graphically in Figures 8.

This study has moderate applicability to the UK. It was conducted in a Western setting, and mean baseline BMIs were similar to those seen in similar ethnic groups in the UK. However, the diagnositic criteria used to identify diabetes cases was not reported.

Stevens 2008[23]*.* 5,980 participants in the Chinese Asian subgroup (mean baseline male BMI 22.0 kg/m^2, female 22.4 kg/m^2; mean follow-up 7.9 to 8.2 years) had an increased risk of incident diabetes in higher BMI categories compared to a reference 18.5 to 23 kg/m^2 category. In the 25.0 to 27.49 kg/m^2 category for American whites the risk difference was +4.6% (95% CI -10.1 to 19.3) close to an equivalent +4.9% (95% CI -30.6 to +40.4) risk difference in the 23.0 to 24.9 kg/m^2 category for the Chinese subgroup. A difference of about -2 kg/m^2 is presented graphically in Figure 9.

This study has moderate applicability to the UK. Mean baseline BMI among Chinese participants was lower than that seen among Chinese populations in the UK, and diabetes diagnosis was based on self-report, which may misclassify cases compared to current UK practice.

Evidence statement Q4.13: BMI cut-points indicating "risk equivalence" for Chinese populations (Type 2 Diabetes)

Q4.13.a: UK or Western Countries

Moderate evidence was found from two cohorts (Chiu, 2011 [+/+]),[22] (Stevens, 2008 [+/+])[23] that for a BMI around 30 kg/m^2 in white populations the equivalent incident diabetes risk in Chinese populations was found at BMI values 2.5 to 5 units lower. In one (Stevens, 2008 [+/+])[23] for a BMI around 25 kg/m^2 in white populations the equivalent incident diabetes risk in Chinese populations was found at BMI values 2 units lower.

These studies have moderate applicability to the UK.

Q4.13.b: Other Countries

One review of studies (Nyamdorj, 2010b [+/++])[25] provides moderate evidence that for a BMI around 30 kg/m^2 in white populations the equivalent incident diabetes risk in Chinese men was found at BMI values 5 kg/m^2 lower for Chinese men and 8 kg/m^2 lower for Chinese women.

This review had moderate applicability to the UK.

Evidence statement Q4.14: WC cut-points indicating "risk equivalence" for Chinese populations (Type 2 Diabetes)

Q4.14.a: UK or Western Countries

No evidence was found relevant to risk equivalent WC cut-points for diabetes in Chinese populations in the UK or other Western populations.

Q4.14.b: Other countries

Moderate graphical evidence was found from one review (Nyamdorj, 2010b [+/++])[25] that a diabetes risk equivalent WC for Chinese men is 82 cm compared to 102 cm in European men, and 67 to 70 cm among Chinese men was found to be risk equivalent to 94 cm among European men. An equivalent diabetes risk is seen among Chinese women at 70 to 73 cm, compared to 88 cm in European women.

This study has moderate applicability to the UK.

No evidence – Chinese populations

Evidence statement Q4.15: BMI cut-points indicating "risk equivalence" for Chinese populations (myocardial infarction, stroke or mortality)
No evidence was found relevant to risk equivalent BMI cut-points for myocardial infarction, stroke or mortality in Chinese populations.

Evidence statement Q4.16: WC cut-points indicating "risk equivalence" for Chinese populations (myocardial infarction, stroke or mortality)
No evidence was found relevant to risk equivalent WC cut-points for myocardial infarction, stroke or mortality in Chinese populations.

4.4.5 Mixed ethnic populations

No studies were identified that identified risk equivalent BMI or WC points between mixed ethnic populations and white populations.

Evidence statement Q4.17: Optimal BMI cut-points for mixed ethnic populations (Type 2 Diabetes)
No evidence was found relevant to risk equivalent WC cut-points for diabetes in mixed ethnic populations.

Evidence statement Q4.18: Optimal WC cut-points for mixed ethnic populations (Type 2 Diabetes)
No evidence was found relevant to risk equivalent BMI cut-points for myocardial infarction, stroke or mortality in mixed ethnic populations.

Evidence statement Q4.19: BMI cut-points indicating "risk equivalence" for mixed ethnic populations (myocardial infarction, stroke or mortality)

No evidence was found relevant to risk equivalent BMI cut-points for myocardial infarction, stroke or mortality in mixed ethnic populations.

Evidence statement Q4.20: WC cut-points indicating "risk equivalence" for mixed ethnic populations (myocardial infarction, stroke or mortality)

No evidence was found relevant to risk equivalent WC cut-points for myocardial infarction, stroke or mortality in mixed ethnic populations.

Table 14: Risk equivalent waist circumference values in black, Asian and minority ethnic populations - 25 kg/m^2

Question 4 BMI 25 kg/m^2	**BMI values with risk equivalency to 25 kg/m^2 in European populations**									
	Black		South Asian		Middle Eastern		Chinese		Mixed Ethnic	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Chiu, 2011	-	-	-	-			-	-		
Stommel, 2010	21-22	21-22								
Nyamdorj, 2010b			-	-			-	-		
Stevens, 2008	23	23					23	23		
Total Range	21-23	21-23	-	-			23	23		
Applicable Range	**21-23**	**21-23**	**-**	**-**			**23**	**23**		

Table 15: Risk equivalent waist circumference values in black, Asian and minority ethnic populations - 30 kg/m^2

Question 4 BMI 30 kg/m^2	**BMI values with risk equivalency to 30 kg/m^2 in European populations**									
	Black		South Asian		Middle Eastern		Chinese		Mixed Ethnic	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Chiu, 2011	26	26	24	24			25	25		
Stommel, 2010	26	26								
Nyamdorj, 2010b			19-20	-			24-25	22		
Stevens, 2008							-	-		
Total Range	26	26	19-24	24			24-25	22-25		
Applicable Range	**26**	**26**	**19-24**	**24**			**24-25**	**22-25**		

Table 16: Risk equivalent waist circumference values in black, Asian and minority ethnic male populations

Question 4 WC Males	WC values with risk equivalency males									
	Black		South Asian		Middle Eastern		Chinese		Mixed Ethnic	
White equivalent	102 cm	94 cm	102 cm	94 cm	102 cm	94 cm	102 cm	94 cm	102 cm	94 cm
Chiu, 2011										
Stommel, 2010										
Nyamdorj, 2010b			73	-			82	67-70		
Stevens, 2008										
Total Range			73				82	67-70		
Applicable Range			**73**				**82**	**67-70**		

Table 17: Risk equivalent waist circumference values in black, Asian and minority ethnic female populations

Question 4 WC Females	WC values with risk equivalency females									
	Black		South Asian		Middle Eastern		Chinese		Mixed Ethnic	
White equivalent	88 cm	80 cm	88 cm	80 cm	88 cm	80 cm	88 cm	80 cm	88 cm	80 cm
Chiu, 2011										
Stommel, 2010										
Nyamdorj, 2010b							70-73			
Stevens, 2008										
Total Range							70-73			
Applicable Range							**70-73**			

5 Discussion

This report addresses an ongoing debate about the interpretation of recommended body-mass index (BMI) or waist circumference cut-off points for determining overweight and obesity in black, Asian and minority ethnic populations in the UK. It reports the evidence that could inform a decision of whether population-specific cut-off points for BMI and or WC are necessary.

Key Messages

Together the research identified that could answer these four questions has methodological limitations and care is needed in interpreting it. The direct applicability to UK populations of much of the data identified may be limited. The cut-off point for observed risk of diabetes varies from 22 kg/m^2 to 25 kg/m^2 in different black, Asian and minority ethnic populations and for high risk it varies from 26 kg/m^2 to 31 kg/m^2. The data is consistent with a 2 to 3 unit reduction in cut-point of BMI for South Asian and Chinese groups, and a 10 cm or more reduction in WC cut-point for South Asian males and Chinese males and females in the UK. The evidence surrounding Middle Eastern populations in the UK indicates that a reduction in BMI and WC may be appropriate, while studies in black populations suggest that an increase in BMI and WC cutoffs may be indicated. However, the evidence in these populations is inconsistent with regards to the the direction and magnitude of risk difference compared to white populations.

5.1 Question 1

Overall, lower BMI and WC are associated with a lower risk for several long term conditions including diabetes and cardiovascular disease.

The accuracy of the anthropometric indices, BMI and WC, in predicting future risk of disease can be assessed by prospective studies that use multivariate analysis or adjusted univariate analysis. Other researchers have developed and tested prediction models that take into account all the risk factors for diabetes, and the prevention of type 2 diabetes and cardiovascular disease have been reviewed in NICE guideance.[26] Some models for predicting diabetes risk already exist and are validated in UK populations.[27]

Cardiovascular scores that include ethnicity as a variable can achieve an AUC of 0.817. Those without ethnicity as a variable and using a modified Framingham equation can also achieve an AUC of 0.80.[26] Refitting of this algorithm for a wider age range has improved AUC for women to 0.853 and for men 0.830.[28] These models would, in theory, provide a benchmark area under the curve (AUC) against which the performance of single anthropometric measures could be compared.

Against this benchmark the range of the AUCs described in this report are moderate. The maximum discriminative power (AUC) of BMI and WC in the studies included in this review was 0.74 for BMI and 0.78 for WC, both amongst black populations. The AUC for BMI in South Asian, Middle Eastern, Chinese and mixed ethnicity populations ranged from 0.61 to 0.69. The AUC for waist circumference in the populations ranged from 0.62 to 0.71. This indicates that existing prediction models, which include ethnicity as a variable, perform better as predictors of Type 2 diabetes than either BMI or WC individually.

Limitations to this interpretation include the fact that not all studies were directly applicable to the UK population. Furthermore, prevalence of disease is an important consideration when assessing the positive predictive value of tests or prediction models and the AUC can vary depending on how well the cut-points are calibrated to the specific population studied.

5.2 Question 2

A healthy BMI range or WC cut-point can be identified by assessing the association between BMI or WC and diabetes, myocardial infarction, stroke or mortality. Above a certain point on this continuous scale, studies have reported the boundary level above which any outcome increase becomes statistically significant.

Using this approach, no appropriate BMI lower boundaries for a healthy range amongst black, Asian and minority ethnic populations in the UK were identified. Individual studies identified upper limits to a healthy population BMI range of approximately 25 kg/m^2 in white populations, 30 kg/m^2 in black populations, 23 kg/m^2 in South Asian populations, 30.5 kg/m^2 in Middle Eastern populations and 22 kg/m^2 in Chinese populations. All of these studies were conducted in non-UK settings, and no upper limit could be identified for black, Asian and ethnic minority populations resident in the UK.

Waist circumference in a single Middle Eastern study had a threshold of about 87 cm for women that could indicate the boundary level above which any diabetes increase becomes statistically significant. Among South Asian populations, a waist circumference of approximately 85 cm for males and 80 cm for females was identified by a single study as an appropriate boundary above which risk of diabetes increases significantly. Another study identified 73 cm as the appropriate WC boundary in Chinese populations. No WC boundaries were found for black populations.

This approach is similar to that adopted by the WHO in its consideration of evidence underlying the original consensus statement on BMI cut-points for defining obesity. However the studies identified in this review do not provide strong evidence for ethnic specific variations in defining the ‘healthy range’ based on this approach.

5.3 Question 3

The cut-points along the scale of anthropometric indices, BMI or WC, that indicate the need for preventative action can be inferred in several ways using ROC analysis. First, the cut-point that results in the highest sensitivity, and therefore fewest people (false negatives), who fall below the threshold of overweight and who go on to develop disease. This method is likely the most appropriate for public health programmes. Only one study presented sensitivity data over the range of BMI values, however. Optimal cut-points were defined in most studies as the point on a ROC curve that relates to maximum sensitivity and specificity (as a trade-off in both). This is an idealised value that results in fewest false negatives and false positives. This threshold is important when considering the point at which preventive interventions or programmes for prevention could be considered. It represents the point at which the fewest people are provided with preventive interventions or treatments unnecessarily and the point at which the fewest people are excluded from an intervention that might benefit them. Selecting such a point is however a trade-off and the utility of any cut-off points identified also depends on the effectiveness of any interventions offered at these points. Assuming this BMI point is 25 kg/m^2, and WC points are 94 cm for men and 80 cm for women in European/white populations, we compared these points as reported in the included studies. Across all studies the optimal cut-point is a BMI between 25 kg/m^2 and 30 kg/m^2, and a WC of approximately 100 cm for males and between 88 and 101 cm for females for diabetes outcomes in black populations. These values were lower for South Asian groups (about a midpoint BMI of 24.5 kg/m^2 and WC of 92 cm for men and women). Studies conducted in Middle Eastern countries showed an optimum cut-point close to BMI 25 kg/m^2 and 88 cm for WC. In Chinese populations the optimal cut-points are slightly lower for both BMI (about 23 to 24 kg/m2) and WC (about 88 cm for males and 83 cm for females). For comparison, cut-points in European or white populations identified in these studies were approximately 27 kg/m^2 for BMI, 100 cm among males and 90 cm among females for waist circumference.

These do not suggest a clear rationale for changing BMI or WC cut-points for an overweight category suitable for targeted prevention in all ethnic groups. There is moderate evidence BMI and WC cut-points should be lower for South Asian and Chinese groups, but the evidence surrounding black and Middle Eastern populations' cut-points is less consistent.

5.4 Question 4

This question seeks to compare the average risks for individuals and populations from different ethnic groups with those expected for European populations at the existing 25 kg/m^2 and 30 kg/m^2 cut-points. The evidence is best inferred from graphs of BMI against incident or prevalent disease by drawing a horizontal line that intersects all plots and is drawn at the level of risk equivalent to a BMI or WC threshold in white populations. Studies are included if they have reported risk in this way and include the relevant ethnic groups compared to white populations.

Incidence and prevalence of diabetes is higher at all BMI and WC cut-points for all minority groups in comparison to white populations. The equivalent risk at a BMI of 30 kg/m^2 in white population occurs in black or south Asian groups up to 6 units lower (BMI). In south Asian groups the equivalent risk at a WC of 102 cm in white male populations occurs at up to 29 cm lower. These studies variably report the additional risk factors that were adjusted for in these analyses. Caution is advised in interpreting the unadjusted incidence and unadjusted prevalence rates which have come from cross-sectional studies. One large US study (Stommel, 2010 [+/+])[24] adjusted for age, sex, education, poverty, marital status, insurance, residency, health behaviours and foreign birth. In these fully adjusted analyses in US populations, similar equivalent BMI or WC equivalents occurred across black, Hispanic, East Asian and white groups (See Figure 8). This could imply that much of the separation of the ethnic specific rates of diabetes, the gap between these curves, is due to confounding by diabetes risk factors other than obesity, and not fully accounted for.

6 Summary

These findings do not support the use of a universal lower BMI cut-off point in all black, Asian and minority ethnic groups for defining overweight or obesity and the preventive interventions that might be offered to people passing these cut-points. With respect to ethnicity specific cut-off points, there was substantial evidence of population-dependent variations in association of disease risk with measures of obesity. South and East Asian populations of greatest interest in this respect, as risks of certain diseases (e.g. diabetes) are notably higher in these populations than would be expected from their mean BMI levels. Understanding the basis for this increased risk of diabetes among these populations is important for identifying the potential environmental causes and the heterogeneity among these populations.

However, populations with BMI greater than or equal to 25 kg/m^2 are rapidly increasing around the world and have substantial risks of disease. To pre-empt the rapid increases in obesity and related health problems that are occurring in South Asian populations a BMI of 23 kg/m^2 and an associated lower waist circumference cut-off, could be justified as suitable action points for public health obesity prevention and control interventions. The WHO consultation identified several potential public health action points (23•0, 27•5, 32•5, and 37•5 kg/m^2) along the continuum of BMI, and proposed methods by which countries could make decisions about the definitions of increased risk for their population. Based on this report a threshold of 23.0 kg/m^2 for South Asian and Chinese groups in the UK is not inconsistent with this approach . The evidence for Middle Eastern and black populations in the UK is less consistent, with evidence for a 2 to 3 unit reduction in BMI as well as evidence supporting no change in BMI and WC cut-points among this population. Among black populations, the direction of the evidence is inconsistent, with some studies indicating tha an optimal BMI and WC cut-point may be higher than those seen in white populations, while other studies indicate that black populations have an equivalent diabetes risk at 2 to 4 BMI units lower than European or white groups.

7 References

1. NICE. Methods for the development of NICE public health guidance (second edition). London: National Institute for Health and Clincial Excellence; 2009. Available from: http://www.nice.org.uk/media/2FB/53/PHMethodsManual110509.pdf.

2. MacKay MF, Haffner SM, Wagenknecht LE et al. Prediction of type 2 diabetes using alternate anthropometric measures in a multi-ethnic cohort. Diabetes Care. 2009 Call for Evidence [Epub ahead of print];32(5):956-8.

3. Sargeant LA, Bennett FI, Forrester TE et al. Predicting incident diabetes in Jamaica: the role of anthropometry. Obesity. 2002;10(8):792-8.

4. Mansour AA, Al-Jazairi MI. Predictors of incident diabetes mellitus in Basrah, Iraq. Annals of Nutrition and Metabolism. 2007;51(3):277-80.

5. Hadaegh F, Zabetian A, Harati H et al. Waist/height ratio as a better predictor of type 2 diabetes compared to body mass index in Tehranian adult men-a 3.6-year prospective study. Experimental and clinical endocrinology and diabetes. 2006;114(6):310.

6. Hadaegh F, Shafiee G, Azizi F. Anthropometric predictors of incident type 2 diabetes mellitus in Iranian women. Annals of Saudi medicine. 2009 Call for Evidence [Epub ahead of print];29(3):194.

7. Janghorbani M, Amini M. Comparison of body mass index with abdominal obesity indicators and waist-to-stature ratio for prediction of type 2 diabetes: The Isfahan diabetes prevention study. Obesity Research & Clinical Practice. 2010;4(1):e25-e32.

8. Taylor HA, Jr., Coady SA, Levy D et al. Relationships of BMI to cardiovascular risk factors differ by ethnicity. Obesity (Silver Spring). 2010;18(8):1638-45.

9. Snehalatha C, Viswanathan V, Ramachandran A. Cutoff values for normal anthropometric variables in asian Indian adults. Diabetes Care. 2003;26(5):1380-4.

10. Thomas GN, Ho SY, Lam KSL et al. Impact of Obesity and Body Fat Distribution on Cardiovascular Risk Factors in Hong Kong Chinese. Obesity. 2004;12(11):1805-13.

11. Qiao Q, Nyamdorj R. The optimal cutoff values and their performance of waist circumference and waist-to-hip ratio for diagnosing type II diabetes. Eur J Clin Nutr. 2010;64(1):23-9.

12. Diaz VA, Mainous AG, Baker R et al. How does ethnicity affect the association between obesity and diabetes? Diabetic Medicine. 2007;24(11):1199-204.

13. Nyamdorj R. Anthropometric measures of obesity-their association with type 2 diabetes and hypertension across ethnic groups PhD by publication. 2010.
Ref Type: Thesis/Dissertation

14. Mohan V, Deepa M, Farooq S et al. Anthropometric cut points for identification of cardiometabolic risk factors in an urban Asian Indian population. Metabolism. 2007;(7):961-8.

15. Jafar TH, Chaturvedi N, Pappas G. Prevalence of overweight and obesity and their association with hypertension and diabetes mellitus in an Indo-Asian population. CMAJ. 2006;2006(9):1071-7.

16. Mirmiran P, Esmaillzadeh A, Azizi F. Detection of cardiovascular risk factors by anthropometric measures in Tehranian adults: receiver operating characteristic (ROC) curve analysis. European journal of clinical nutrition. 2004;58(8):1110-8.

17. Mansour AA, Al-Jazairi MI. Cut-off values for anthropometric variables that confer increased risk of type 2 diabetes mellitus and hypertension in Iraq. Archives of medical research. 2007;38(2):253-8.

18. Sarrafzadegan N, Kelishadi R, Najafian A et al. Anthropometric indices in association with cardiometabolic risk factors: findings of the Isfahan Healthy Heart Program. ARYA Atherosclerosis. 2010;5(4).

19. Ko GT, Chan JC, Cockram CS et al. Prediction of hypertension, diabetes, dyslipidaemia or albuminuria using simple anthropometric indexes in Hong Kong Chinese. Int J Obes Relat Metab Disord. 1999;(11):1136-42.

20. Ho SY, Lam TH, Janus ED. Waist to stature ratio is more strongly associated with cardiovascular risk factors than other simple anthropometric indices. Annals of Epidemiology. 2003;13(10):683-91.

21. Huxley R, James WPT, Barzi F et al. Ethnic comparisons of the cross-sectional relationships between measures of body size with diabetes and hypertension. Obesity Reviews. 2008;9:53-61.

22. Chiu M, Austin PC, Manuel DG et al. Deriving ethnic-specific BMI cutoff points for assessing diabetes risk. Diabetes Care. 2011;2011(8):1741-8.

23. Stevens J, Truesdale KP, Katz EG et al. Impact of body mass index on incident hypertension and diabetes in Chinese Asians, American Whites, and American Blacks: the People's Republic of China Study and the Atherosclerosis Risk in Communities Study. Am J Epidemiol. 2008;167(11):1365-74.

24. Stommel M, Schoenborn CA. Variations in BMI and prevalence of health risks in diverse racial and ethnic populations. Obesity (Silver Spring). 2010;18(9):1821-6.

25. Nyamdorj R, Pitkaniemi J, Tuomilehto J et al. Ethnic comparison of the association of undiagnosed diabetes with obesity. Int J Obes (Lond). 2010;34(2):332-9.

26. NICE. Preventing type 2 diabetes: population and community-level interventions. PH35. London: National Institute of Clinical Excellence; 2011. Available from: http://www.nice.org.uk/nicemedia/live/13472/54345/54345.pdf.

27. Hippisley-Cox J, Coupland C, Robson J et al. Predicting risk of type 2 diabetes in England and Wales: prospective derivation and validation of QDScore. BMJ. 2009;338:b880.

28. Hippisley-Cox J, Coupland C, Robson J et al. Advantages of QRISK2 (2010): the key issue is ethnicity and extent of reallocation. Heart. 2011;97(6):515-6.

29. WHO. Obesity and overweight. Fact sheet 311. Geneva: World Health Organisation; 2011. Available from: http://www.who.int/mediacentre/factsheets/fs311/en/.

30. WHO. Obesity: preventing and managing the global epidemic: report of a WHO consultation. Geneva: World Health Organisation; 2000. Available from: http://www.who.int/nutrition/publications/obesity/WHO_TRS_894/en/.

31. ONS. Population Estimates by Ethnic Group 2002 – 2009. Newport: Office for National Statistics; 2011. Available from: http://www.ons.gov.uk/ons/rel/peeg/population-estimates-by-ethnic-group--experimental-/current-estimates/population-density--change-and-concentration-in-great-britain.pdf.

32. NOO. Obesity and Ethnicity. Oxford: National Obesity Observatory; 2011. Available from: http://www.noo.org.uk/NOO_about_obesity/measurement.

33. White A. Social Focus in Brief: Ethnicity. Newport: Office for National Statistics; 2002. Available from: http://www.ons.gov.uk/ons/rel/ethnicity/social-focus-in-brief--ethnicity/full-report/full-report---ethnicity.pdf.

34. NOO. Measurement of Obesity [internet]. Oxford: National Obesity Observatory; 2010 [updated 2010; cited 2012 May 17]. Available from: http://www.noo.org.uk/NOO_about_obesity/measurement.

35. Chan RS, Woo J. Prevention of overweight and obesity: how effective is the current public health approach. Int J Environ Res Public Health. 2010;7(3):765-83.

36. Gill T. Epidemiology and health impact of obesity: an Asia Pacific perspective. Asia Pac J Clin Nutr. 2006;15 Suppl:3-14.

37. Low S, Chin MC, Deurenberg-Yap M. Review on epidemic of obesity. Ann Acad Med Singapore. 2009;38(1):57-9.

38. Asia Pacific Cohort Studies Collaboration. The burden of overweight and obesity in the Asia-Pacific region. Obes Rev. 2007;8(3):191-6.

39. WHO. Global health observatory - mean body mass index (BMI) [website on the internet]2012 [updated 2012; cited 2012 May 30]. Available from: http://www.who.int/gho/ncd/risk_factors/bmi_text/en/index.html.

40. NAO. Tackling Obesity in England. London: National Audit Office; 2001. Available from: http://www.nao.org.uk//idoc.ashx?docId=7b694854-588f-4d45-a968-ebb0439de6b2&version=-1.

41. NHS Information Centre. Health survey for England 2010: Adult trend tables. NHS Health and Social Care Information Centre; 2011. Available from: http://www.ic.nhs.uk/cmsincludes/_process_document.asp?sPublicationID=1323774647909&sDocID=7213.

42. NHS Information Centre. Health survey for England 2010: Child trend tables. NHS Health and Social Care Information Centre; 2011. Available from: http://www.ic.nhs.uk/cmsincludes/_process_document.asp?sPublicationID=1323774647909&sDocID=7214.

43. McPherson K, Marsh T, Brown M. Tackling Obesities: Future Choices - Modelling Future Trends in Obesity & Their Impact on Health, 2nd Edition. Foresight. London: Government Office for Science; 2007. Available from: http://www.bis.gov.uk/assets/foresight/docs/obesity/14.pdf.

44. Minet KJ, Morris S. Socioeconomic variation in the impact of obesity on health-related quality of life. Soc Sci Med. 2010;71(10):1864-71.

45. NHS Information Centre. Health survey for England 2004: The health of minority ethnic groups – headline tables. Leeds: NHS Health and Social Care Information Centre; 2005. Available from: http://www.ic.nhs.uk/webfiles/publications/hlthsvyeng2004ethnic/HealthSurveyForEngland161205_PDF%20.pdf.

46. Ramachandran A, Snehalatha C, Mary S et al. The Indian Diabetes Prevention Programme shows that lifestyle modification and metformin prevent type 2 diabetes in Asian Indian subjects with impaired glucose tolerance (IDPP-1). Diabetologia. 2006;49(2):289-97.

47. NHS Information Centre. Statistics on obesity, physical activity and diet: England, 2006. Leeds: NHS Health and Social Care Information Centre; 2006. Available from: http://www.ic.nhs.uk/webfiles/publications/opan06/OPAN%20bulletin%20finalv2.pdf.

48. NOO. Measures of central adiposity as an indicator of obesity. Oxford: National Obesity Observatory; 2009. Available from: http://www.noo.org.uk/uploads/doc/vid_5187_MEASURESOFCENTRALADIPOSITYAugust%2009_updated%20Feb%202010.pdf.

49. NOO. Body mass index as a measure of obesity. Oxford: National Obesity Observatory; 2009. Available from: http://www.noo.org.uk/uploads/doc789_40_noo_BMI.pdf.

50. NICE. Obesity: full guideline, section 2 - identification and classification: evidence statements and reviews. CG43. London: National Institute of Clinical Excellence; 2007. Available from: http://www.nice.org.uk/nicemedia/live/11000/38295/38295.pdf.

51. Ashwell M. Waist to height ratio and the Ashwell® shape chart could predict the health risks of obesity in adults and children in all ethnic groups. Nutrition and food science. 2005;35(5):359-64.

52. WHO expert consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet. 2004;2004(9403):157-63.

53. Alberti KG, Zimmet P, Shaw J. International Diabetes Federation: a consensus on Type 2 diabetes prevention. Diabet.Med. 2007;24(5):451-63.

54. NICE. The guidelines manual 2009. London: National Institute for Health and Clinical Excellence; 2009. Available from: http://www.nice.org.uk/guidelinesmanual?domedia=1&mid=5F238D80-19B9-E0B5-D4CB1191544B5D45.

55. Shah A, Bhandary S, Malik SL et al. Waist circumference and waist-hip ratio as predictors of type 2 diabetes mellitus in the Nepalese population of Kavre District. Nepal Med Coll J. 2009;11(4):261-7.

56. Zaher ZM, Zambari R, Pheng CS et al. Optimal cut-off levels to define obesity: body mass index and waist circumference, and their relationship to cardiovascular disease, dyslipidaemia, hypertension and diabetes in Malaysia. Asia Pacific Journal of Clinical Nutrition. 2009;18(2):209-16.

57. Almajwal AM, Al-Baghli NA, Batterham MJ et al. Performance of body mass index in predicting diabetes and hypertension in the Eastern Province of Saudi Arabia. Annals of Saudi medicine. 2009;29(6):437.

Appendix 2 – Excluded studies

PHASE I

Excluded - population

1 Balkau B, Sapinho D, Petrella A et al. Prescreening tools for diabetes and obesity-associated dyslipidaemia: comparing BMI, waist and waist hip ratio. The DESIR Study. European journal of clinical nutrition. 2005;60(3):295-304.

2 Collaboration APCS. A comparison of the associations between risk factors and cardiovascular disease in Asia and Australasia. European Journal of Cardiovascular Prevention & Rehabilitation. 2005;12(5):484-91.

3 Cox BD, Whichelow MJ, Ashwell MA et al. Comparison of anthropometric indices as predictors of mortality in British adults. Int J Obes Relat Metab Disord. 1996;20(Suppl 4):141.

4 Ito H, Nakasuga K, Ohshima A et al. Detection of cardiovascular risk factors by indices of obesity obtained from anthropometry and dual-energy X-ray absorptiometry in Japanese individuals. Int J Obes Relat Metab Disord. 2003;(2):232-7.

5 Jee SH, Sull JW, Park J et al. Body-mass index and mortality in Korean men and women. N Engl.J Med. 2006;355(8):779-87.

6 Kim Y, Suh YK, Choi H. BMI and metabolic disorders in South Korean adults: 1998 Korea National Health and Nutrition Survey. Obes.Res. 2004;12(3):445-53.

7 Lara-Esqueda A, Aguilar-Salinas CA, Velazquez-Monroy O et al. The body mass index is a less-sensitive tool for detecting cases with obesity-associated co-morbidities in short stature subjects. Int J Obes.Relat.Metab.Disord. 2004;28(11):1443-50.

8 Lim U, Ernst T, Buchthal SD et al. Asian women have greater abdominal and visceral adiposity than Caucasian women with similar body mass index. Nutrition and Diabetes. 2011;1:e6.

9 Nakamura K, Nanri H, Hara M et al. Optimal cutoff values of waist circumference and the discriminatory performance of other anthropometric indices to detect the clustering of cardiovascular risk factors for metabolic syndrome in Japanese men and women. Environ.Health Prev.Med. 2011;16(1):52-60.

10 Nakata K, Choo J, Hopson MJS et al. Stronger associations of sagittal abdominal diameter with atherogenic lipoprotein subfractions than waist circumference in middle-aged US white and Japanese men. Metabolism. 2010 Call for Evidence [Epub ahead of print];59(12):1742-51.

11 Paniagua L, Lohsoonthorn V, Lertmaharit S et al. Comparison of waist circumference, body mass index, percent body fat and other measure of adiposity in identifying cardiovascular disease risks among Thai adults. Obesity Research & Clinical Practice. 2008;2(3):215-23.

12 Park HS, Yun YS, Park JY et al. Obesity, abdominal obesity, and clustering of cardiovascular risk factors in South Korea. Asia Pac.J Clin Nutr. 2003;12(4):411-8.

13 Park JH, Yoon SJ, Lee H et al. Burden of disease attributable to obesity and overweight in Korea. Int J Obes.(Lond). 2006;30(11):1661-9.

14 Park SH, Choi SJ, Lee KS et al. Waist circumference and waist-to-height ratio as predictors of cardiovascular disease risk in Korean adults. Circ.J. 2009;73(9):1643-50.

15 Pongchaiyakul C, Pongchaiyakul C, Wanothayaroj E et al. Association between waist circumference and percentage body fat among rural Thais. J Med Assoc Thai. 2006;89(10):1592-600.

16 Pouliot MC, Despr+®s JP, Lemieux S et al. Waist circumference and abdominal sagittal diameter: best simple anthropometric indexes of abdominal visceral adipose tissue accumulation and related cardiovascular risk in men and women. The American journal of cardiology. 1994;73(7):460-8.

17 Ris®rus U, +ärnl+Âv J, Berglund L. Long-Term Predictors of Insulin Resistance. Diabetes Care. 2007;30(11):2928-33.

18 Song YM, Ha M, Sung J. Body mass index and mortality in middle-aged Korean women. Annals of Epidemiology. 2007;17(7):556-63.

19 Steinbrecher A, Morimoto Y, Heak S et al. The preventable proportion of type 2 diabetes by ethnicity: the multiethnic cohort. Annals of Epidemiology. 2011.

Appendix 2 – Excluded studies

Excluded - exposure

1 Anand SS, Ounpuu S, Yusuf S. Ethnicity and cardiovascular disease. In: S.Yusuf JCACEFaBG, editor. Evidence-based Cardiology. 2 ed. Wiley Online Library; 1998. p. 259-278.

2 Anand SS, Tarnopolsky MA, Rashid S et al. Adipocyte hypertrophy, fatty liver and metabolic risk factors in South Asians: the Molecular Study of Health and Risk in Ethnic Groups (mol-SHARE). PLoS One. 2011;6(7):e22112.

3 Barnett AH, Dixon AN, Bellary S et al. Type 2 diabetes and cardiovascular risk in the UK south Asian community. Diabetologia. 2006;49(10):2234-46.

4 Bhopal R, Unwin N, White M et al. Heterogeneity of coronary heart disease risk factors in Indian, Pakistani, Bangladeshi, and European origin populations: cross sectional study. BMJ. 1999;319(7204):215-20.

5 Ganesh R, Leese T, Rao AD et al. Laparoscopic adjustable gastric banding for severe obesity. Singapore Med J. 2006;47(8):661-9.

6 Holman N, Forouhi NG, Goyder E et al. The Association of Public Health Observatories (APHO) Diabetes Prevalence Model: estimates of total diabetes prevalence for England, 2010-2030. Diabet.Med. 2011;28(5):575-82.

7 Joshi P, Islam S, Pais P et al. Risk factors for early myocardial infarction in South Asians compared with individuals in other countries. JAMA. 2007;297(3):286-94.

8 Lear SA, Toma M, Birmingham CL et al. Modification of the relationship between simple anthropometric indices and risk factors by ethnic background. Metabolism. 2003;52(10):1295-301.

9 Lear SA, Kohli S, Bondy GP et al. Ethnic variation in fat and lean body mass and the association with insulin resistance. J Clin Endocrinol.Metab. 2009;94(12):4696-702.

10 McNeely MJ, Boyko EJ. Type 2 diabetes prevalence in Asian Americans: results of a national health survey. Diabetes Care. 2004;27(1):66-9.

11 Park JH, Yoon SJ, Lee H et al. Burden of disease attributable to obesity and overweight in Korea. Int J Obes.(Lond). 2006;30(11):1661-9.

12 Shai I, Jiang R, Manson JAE et al. Ethnicity, obesity, and risk of type 2 diabetes in women. Diabetes Care. 2006;29(7):1585-90.

13 Srinivasan B. Characteristics of Prediabetes, predictors of progression and strategies to prevent Type 2 Diabetes Mellitus in a multiethnic population in the United Kingdom. 2011. University of Leicester. 11-5-2012. Ref Type: Thesis/Dissertation

14 Tong PCY, Lee ZSK, Sea MM et al. The effect of orlistat-induced weight loss, without concomitant hypocaloric diet, on cardiovascular risk factors and insulin sensitivity in young obese Chinese subjects with or without type 2 diabetes. Archives of internal medicine. 2002;162(21):2428.

15 Wang Y, Mi J, Shan XY et al. Is China facing an obesity epidemic and the consequences? The trends in obesity and chronic disease in China. Int J Obes (Lond). 2007;31(1):177-88.

16 Zhang X, Shu XO, Yang G et al. Abdominal adiposity and mortality in Chinese women. Archives of internal medicine. 2007;167(9):886.

Excluded - outcome

1 Al-Lawati JA, Barakat NM, Al-Lawati AM et al. Optimal cut-points for body mass index, waist circumference and waist-to-hip ratio using the Framingham coronary heart disease risk score in an Arab population of the Middle East. Diab.Vasc.Dis Res. 2008;5(4):304-9.

2 Alboqai O, Suleiman A, Al Hourani H et al. CENTRAL ADIPOSITY RATHER THAN OVERALL OBESITY INFLUENCES CARDIO-METABOLIC RISK FACTORS AMONG ADULT MALES IN NORTHERN JORDAN. Diabetologia Croatica. 2009;38(3):73-82.

3 Barnett AH, Dixon AN, Bellary S et al. Type 2 diabetes and cardiovascular risk in the UK south Asian community. Diabetologia. 2006;49(10):2234-46.

4 Bhat DS, Yajnik CS, Sayyad MG et al. Body fat measurement in Indian men: comparison of three methods based on a two-compartment model. Int J Obes.(Lond). 2005;29(7):842-8.

5 Chakraborty R, Bose K. Central adiposity, body mass index and percent body fat among Bengalee Hindu male slum dwellers of Dum Dum, West Bengal, India. Open Obesity Journal. 2009;1:32-7.

Bazian

6 Chen YM, Ho SC, Lam SS et al. Validity of body mass index and waist circumference in the classification of obesity as compared to percent body fat in Chinese middle-aged women. Int J Obes.(Lond.). 2006;30(6):918-25.

7 Deepa M, Farooq S, Deepa R et al. Prevalence and significance of generalized and central body obesity in an urban Asian Indian population in Chennai, India (CURES: 47). European journal of clinical nutrition. 2007;63(2):259-67.

8 Deurenberg-Yap M, Schmidt G, van Staveren WA et al. The paradox of low body mass index and high body fat percentage among Chinese, Malays and Indians in Singapore. International Journal of Obesity. 2000;24(8):1011-7.

9 Deurenberg-Yap M, Chew SK, Deurenberg P. Elevated body fat percentage and cardiovascular risks at low body mass index levels among Singaporean Chinese, Malays and Indians. Obes Rev. 2002;(3):209-15.

10 Deurenberg P, Deurenberg-Yap M. Differences in body-composition assumptions across ethnic groups: practical consequences. Current Opinion in Clinical Nutrition & Metabolic Care. 2001;4(5):377.

11 Evans J, Micklesfield L, Jennings C et al. Diagnostic Ability of Obesity Measures to Identify Metabolic Risk Factors in South African Women. Metabolic Syndrome and Related Disorders. 2011.

12 Gallagher D, Heymsfield SB, Heo M et al. Healthy percentage body fat ranges: an approach for developing guidelines based on body mass index. Am J Clin Nutr. 2000;72(3):694-701.

13 Ganesh R, Leese T, Rao AD et al. Laparoscopic adjustable gastric banding for severe obesity. Singapore Med J. 2006;47(8):661-9.

14 Hadaegh F, Zabetian A, Harati H et al. Metabolic syndrome in normal-weight Iranian adults. Annals of Saudi medicine. 2007;27(1):18.

15 Hadaegh F, Zabetian A, Sarbakhsh P et al. Appropriate cutoff values of anthropometric variables to predict cardiovascular outcomes: 7.6 years follow-up in an Iranian population. International Journal of Obesity. 2009;33(12):1437-45.

16 Harland JO, Unwin N, Bhopal RS et al. Low levels of cardiovascular risk factors and coronary heart disease in a UK Chinese population. J Epidemiol Community Health. 1997;51(6):636-42.

17 He M, Li ETS, Harris S et al. Canadian global village reality. Canadian Family Physician. 2010;56(5):e174-e182.

18 Hegazi MA, Al-Kadi HA, Alissa EM. The influence of waist circumference and body mass index on the levels of adipokines, insulin and lipid parameters in normal overweight young Saudi females. International Journal of Medicine and Medical Sciences. 2011;3(13):364-72.

19 Hu FB, Wang B, Chen C et al. Body mass index and cardiovascular risk factors in a rural Chinese population. Am J Epidemiol. 2000;2000(1):88-97.

20 Joseph L, Wasir JS, Misra A et al. Appropriate values of adiposity and lean body mass indices to detect cardiovascular risk factors in Asian Indians. Diabetes technology & therapeutics. 2011;13(9):899-906.

21 Katulanda P, Jayawardena MAR, Sheriff MHR et al. Derivation of anthropometric cut-off levels to define CVD risk in Sri Lankan adults. British Journal of Nutrition. 2011;105(07):1084-90.

22 Katzmarzyk PT, Bray GA, Greenway FL et al. Ethnic-specific BMI and waist circumference thresholds. Obesity. 2011;19(6):1272-8.

23 Khader YS, Batieha A, Jaddou H et al. Anthropometric cutoff values for detecting metabolic abnormalities in Jordanian adults. Diabetes, metabolic syndrome and obesity: targets and therapy. 2010;3:395.

24 Kulkarni B, Shatrugna V, Nagalla B et al. Regional body composition of Indian women from a low-income group and its association with anthropometric indices and reproductive events. Annals of Nutrition and Metabolism. 2010;56(3):182-9.

25 Kurpad AV. Body composition and BMI criterion for Indians. NFI BULLETIN. 2005;26(4):1.

26 Lear SA, Toma M, Birmingham CL et al. Modification of the relationship between simple anthropometric indices and risk factors by ethnic background. Metabolism. 2003;52(10):1295-301.

27 Lear SA, Humphries KH, Kohli S et al. The use of BMI and waist circumference as surrogates of body fat differs by ethnicity. Obesity (Silver Spring). 2007;2007(11):2817-24.

Appendix 2 – Excluded studies

28 Lear SA, Kohli S, Bondy GP et al. Ethnic variation in fat and lean body mass and the association with insulin resistance. J Clin Endocrinol.Metab. 2009;94(12):4696-702.

29 Lee J, Heng D, Chia KS et al. Risk factors and incident coronary heart disease in Chinese, Malay and Asian Indian males: the Singapore Cardiovascular Cohort Study. Int J Epidemiol. 2001;30(5):983-8.

30 Liu Y, Tong G, Tong W et al. Can body mass index, waist circumference, waist-hip ratio and waist-height ratio predict the presence of multiple metabolic risk factors in Chinese subjects? BMC Public Health. 2011;11(1):35.

31 Mellati AA, Mousavinasab SN, Sokhanvar S et al. Correlation of anthropometric indices with common cardiovascular risk factors in an urban adult population of Iran: data from Zanjan Healthy Heart Study. Asia Pacific Journal of Clinical Nutrition. 2009;18(2):217.

32 Nakamura K, Nanri H, Hara M et al. Optimal cutoff values of waist circumference and the discriminatory performance of other anthropometric indices to detect the clustering of cardiovascular risk factors for metabolic syndrome in Japanese men and women. Environ.Health Prev.Med. 2011;16(1):52-60.

33 Nakata K, Choo J, Hopson MJS et al. Stronger associations of sagittal abdominal diameter with atherogenic lipoprotein subfractions than waist circumference in middle-aged US white and Japanese men. Metabolism. 2010 Call for Evidence [Epub ahead of print];59(12):1742-51.

34 Nguyen TT, Adair LS, He K et al. Optimal cutoff values for overweight: using body mass index to predict incidence of hypertension in 18- to 65-year-old Chinese adults. J Nutr. 2008;2008(7):1377-82.

35 Nguyen TT, Adair LS, Suchindran CM et al. The association between body mass index and hypertension is different between East and Southeast Asians. Am J Clin Nutr. 2009;89(6):1905-12.

36 Nichols SD, Crichlow H. An evaluation of the diagnostic utility of anthropometric and body composition cut-off values in assessing elevated fasting blood sugar and blood pressure. West Indian Medical Journal. 2010;59(3):253.

37 O'Connor DP, Bray MS, McFarlin BK et al. Ethnic bias in anthropometric estimates of DXA abdominal fat: the TIGER study. Med Sci Sports Exerc. 2011;43(9):1785-90.

38 Okorodudu DO, Jumean MF, Montori VM et al. Diagnostic performance of body mass index to identify obesity as defined by body adiposity: a systematic review and meta-analysis. International Journal of Obesity. 2010;34(5):791-9.

39 Page JH, Rexrode KM, Hu F et al. Waist-height ratio as a predictor of coronary heart disease among women. Epidemiology. 2009;20(3):361.

40 Palaniappan LP, Wong EC, Shin JJ et al. Asian Americans have greater prevalence of metabolic syndrome despite lower body mass index. International Journal of Obesity. 2010;35(3):393-400.

41 Paniagua L, Lohsoonthorn V, Lertmaharit S et al. Comparison of waist circumference, body mass index, percent body fat and other measure of adiposity in identifying cardiovascular disease risks among Thai adults. Obesity Research & Clinical Practice. 2008;2(3):215-23.

42 Park YW, Allison DB, Heymsfield SB et al. Larger amounts of visceral adipose tissue in Asian Americans. Obes.Res. 2001;9(7):381-7.

43 Parr CL, Batty GD, Lam TH et al. Body-mass index and cancer mortality in the Asia-Pacific Cohort Studies Collaboration: pooled analyses of 424,519 participants. Lancet Oncol. 2010;11(8):741-52.

44 Patel JV, Vyas A, Cruickshank JK et al. Impact of migration on coronary heart disease risk factors: comparison of Gujaratis in Britain and their contemporaries in villages of origin in India. Atherosclerosis. 2006;185(2):297-306.

45 Patel S, Unwin N, Bhopal R et al. A comparison of proxy measures of abdominal obesity in Chinese, European and South Asian adults. Diabet Med. 1999;16(10):853-60.

46 Patil VC, Parale GP, Kulkarni PM et al. Relation of anthropometric variables to coronary artery disease risk factors. Indian Journal of Endocrinology and Metabolism. 2011 Call for Evidence [Epub ahead of print];15(1):31.

47 Pongchaiyakul C, Pongchaiyakul C, Wanothayaroj E et al. Association between waist circumference and percentage body fat among rural Thais. J Med Assoc Thai. 2006;89(10):1592-600.

Appendix 2 – Excluded studies

48 Prinsloo J, Malan L, de Ridder JH et al. Determining the Waist Circumference Cut off which Best Predicts the Metabolic Syndrome components in urban Africans: The SABPA study. Experimental and clinical endocrinology & diabetes. 2011;119(10):599-603.

49 Razak F, Anand S, Vuksan V et al. Ethnic differences in the relationships between obesity and glucose-metabolic abnormalities: a cross-sectional population-based study. Int J Obes.(Lond.). 2005;29(6):656-67.

50 Razak F, Anand SS, Shannon H et al. Defining obesity cut points in a multiethnic population. Circulation. 2007;(16):2111-8.

51 Ris®rus U, +ärnl+Âv J, Berglund L. Long-Term Predictors of Insulin Resistance. Diabetes Care. 2007;30(11):2928-33.

52 Rush EC, Goedecke JH, Jennings C et al. BMI, fat and muscle differences in urban women of five ethnicities from two countries. Int J Obes.(Lond.). 2007;31(8):1232-9.

53 Rush EC, Freitas I, Plank LD. Body size, body composition and fat distribution: comparative analysis of European, Maori, Pacific Island and Asian Indian adults. British Journal of Nutrition. 2010;102(4):632.

54 Singh SP, Sikri G, Garg MK. Body mass index and obesity: Tailoring "cut-off" for an Asian Indian male population. Medical Journal Armed Forces India. 2008;64(4):350-3.

55 So WY, Yang X, Ma RCW et al. Risk factors in V-shaped risk associations with all cause mortality in type 2 diabetes The Hong Kong Diabetes Registry. Diabetes/metabolism research and reviews. 2008;24(3):238-46.

56 Stults-Kolehmainen MA, Stanforth PR, Bartholomew JB. Fat in Android, Trunk, and Peripheral Regions Varies by Ethnicity and Race in College Aged Women. Obesity. 2011.

57 Sun Q, van Dam RM, Spiegelman D et al. Comparison of dual-energy x-ray absorptiometric and anthropometric measures of adiposity in relation to adiposity-related biologic factors. American journal of epidemiology. 2010;172(12):1442-54.

58 TALAEI AFSANEH A, ALIKHANI S, DELAVARI ALIR et al. WAIST CIRCUMFERENCE CUT OFF IN RELATION TO HYPERTENSION IN IRAN. IRANIAN JOURNAL OF ENDOCRINOLOGY AND METABOLISM (IJEM). 2008.

59 Talaei M, Thomas GN, Marshall T et al. Appropriate cut-off values of waist circumference to predict cardiovascular outcomes: 7-year follow-up in an Iranian population. Intern Med. 2012;51(2):139-46.

60 Tong PCY, Lee ZSK, Sea MM et al. The effect of orlistat-induced weight loss, without concomitant hypocaloric diet, on cardiovascular risk factors and insulin sensitivity in young obese Chinese subjects with or without type 2 diabetes. Archives of internal medicine. 2002;162(21):2428.

61 Tseng CH. Waist-to-height ratio and coronary artery disease in Taiwanese type 2 diabetic patients. Obesity. 2008 Call for Evidence [Epub ahead of print];16(12):2754-9.

62 Wang W, Luo Y, Liu Y et al. Prevalence of metabolic syndrome and optimal waist circumference cut-off points for adults in Beijing. Diabetes research and clinical practice. 2010;88(2):209-16.

63 Wang Y, Mi J, Shan XY et al. Is China facing an obesity epidemic and the consequences? The trends in obesity and chronic disease in China. Int J Obes (Lond). 2007;31(1):177-88.

64 Wang Z, Ma J, Si D. Optimal cut-off values and population means of waist circumference in different populations. Nutrition research reviews. 2010;23(2):191.

65 Weng X, Liu Y, Ma J et al. Use of body mass index to identify obesity-related metabolic disorders in the Chinese population. Eur J Clin Nutr. 2006;60(8):931-7.

66 Wu CH, Heshka S, Wang J et al. Truncal fat in relation to total body fat: influences of age, sex, ethnicity and fatness. Int J Obes.(Lond.). 2007;31(9):1384-91.

67 Zhu S, Heymsfield SB, Toyoshima H et al. Race-ethnicity□Çôspecific waist circumference cutoffs for identifying cardiovascular disease risk factors. The American journal of clinical nutrition. 2005;81(2):409-15.

Appendix 2 – Excluded studies

Excluded - analysis

1 Babusik P, Duris I. Comparison of obesity and its relationship to some metabolic risk factors of atherosclerosis in Arabs and South Asians in Kuwait. Med Princ.Pract. 2010;19(4):275-80.

2 Collaboration APCS. Body mass index and cardiovascular disease in the Asia-Pacific Region: an overview of 33 cohorts involving 310 000 participants. International journal of epidemiology. 2004;33(4):751-8.

3 Collaboration APCS. A comparison of the associations between risk factors and cardiovascular disease in Asia and Australasia. European Journal of Cardiovascular Prevention & Rehabilitation. 2005;12(5):484-91.

4 Collaboration APCS. Central obesity and risk of cardiovascular disease in the Asia Pacific Region. Asia Pac J Clin Nutr. 2006;15(3):287-92.

5 COLLABORATION OINA. Waist circumference thresholds provide an accurate and widely applicable method for the discrimination of diabetes. Diabetes Care. 2007;30(12).

6 de Koning L, Gerstein HC, Bosch J et al. Anthropometric measures and glucose levels in a large multi-ethnic cohort of individuals at risk of developing type 2 diabetes. Diabetologia. 2010;53(7):1322-30.

7 Deepa M, Farooq S, Deepa R et al. Prevalence and significance of generalized and central body obesity in an urban Asian Indian population in Chennai, India (CURES: 47). European journal of clinical nutrition. 2007;63(2):259-67.

8 Deurenberg-Yap M, Chew SK, Lin VF et al. Relationships between indices of obesity and its co-morbidities in multi-ethnic Singapore. Int J Obes Relat Metab Disord. 2001;25(10):1554-62.

9 Esmaillzadeh A, Mirmiran P, Azizi F. Waist-to-hip ratio is a better screening measure for cardiovascular risk factors than other anthropometric indicators in Tehranian adult men. International Journal of Obesity. 2004;28(10):1325-32.

10 Esmaillzadeh A, Mirmiran P, Azizi F. Comparative evaluation of anthropometric measures to predict cardiovascular risk factors in Tehranian adult women. Public health nutrition. 2006;9(01):61-9.

11 Fezeu L, Balkau B, Sobngwi E et al. Waist circumference and obesity-related abnormalities in French and Cameroonian adults: the role of urbanization and ethnicity. International Journal of Obesity. 2010;34(3):446-53.

12 Garduno-Diaz SD, Khokhar S. Prevalence, risk factors and complications associated with type 2 diabetes in migrant South Asians. Diabetes Metabolism Research and Reviews. 2012;28(1):6-24.

13 Gupta R, Sarna M, Rastogi P et al. Association of Obesity with Coronary Risk Factors in the North Indian Bhatia Community: Jaipur Heart Watch-3. Human Ecology. 2005;SI13:101-10.

14 Gupta R, Rastogi P, Sarna M et al. Body-mass index, waist-size, waist-hip ratio and cardiovascular risk factors in urban subejcts [sic]. JAPI. 2007;55:621-7.

15 Hadaegh F, Zabetian A, Harati H et al. Metabolic syndrome in normal-weight Iranian adults. Annals of Saudi medicine. 2007;27(1):18.

16 Kelishadi R, Gharipour M, Sadri GH et al. Cardiovascular disease risk factors, metabolic syndrome and obesity in an Iranian population. East Mediterr Health J. 2008;14(5):1070-9.

17 Ko GTC, Chan JCN, Chow CC et al. Effects of obesity on the conversion from normal glucose tolerance to diabetes in Hong Kong Chinese. Obesity. 2004;12(6):889-95.

18 Kurpad AV. Body composition and BMI criterion for Indians. NFI BULLETIN. 2005;26(4):1.

19 Lear SA, Humphries KH, Kohli S et al. The use of BMI and waist circumference as surrogates of body fat differs by ethnicity. Obesity (Silver Spring). 2007;2007(11):2817-24.

20 Lee CMY, Huxley RR, Wildman RP et al. Indices of abdominal obesity are better discriminators of cardiovascular risk factors than BMI: a meta-analysis. Journal of clinical epidemiology. 2008;61(7):646-53.

21 Lee ZSK, Critchley J, Ko GTC et al. Obesity and cardiovascular risk factors in Hong Kong Chinese. Obesity Reviews. 2002;3(3):173-82.

22 Low S, Chin MC, Ma S et al. Rationale for redefining obesity in Asians. Ann Acad Med Singapore. 2009;2009(1):66-9.

23 Mathe N. Adisposity and CVD risk factors: A comparison between ethnicities. 2010. Buckinghamshire New University.
Ref Type: Thesis/Dissertation

24 Misra A, Vikram NK, Gupta R et al. Waist circumference cutoff points and action levels for Asian Indians for identification of abdominal obesity. International Journal of Obesity. 2005;30(1):106-11.

25 Nyamdorj R QQLTTJHSPJNTMVJEFS. BMI compared with central obesity indicators in relation to diabetes and hypertension in Asians. Obesity. 2008;16(7):1622-35.

26 Qiao Q, Nyamdorj R. Is the association of type II diabetes with waist circumference or waist-to-hip ratio stronger than that with body mass index index. European journal of clinical nutrition. 2009;64(1):30-4.

27 Razak F, Anand S, Vuksan V et al. Ethnic differences in the relationships between obesity and glucose-metabolic abnormalities: a cross-sectional population-based study. Int J Obes.(Lond.). 2005;29(6):656-67.

28 Razak F, Anand SS, Shannon H et al. Defining obesity cut points in a multiethnic population. Circulation. 2007;(16):2111-8.

29 Shen W, Punyanitya M, Chen J et al. Waist Circumference Correlates with Metabolic Syndrome Indicators Better Than Percentage Fat. Obesity. 2006;14(4):727-36.

30 Stevens J, Truesdale KP, Wang CH et al. Body mass index at age 25 and all-cause mortality in whites and African Americans: the Atherosclerosis Risk in Communities study. J Adolesc Health. 2012;50(3):221-7.

31 Vikram NK, Pandey RM, Misra A et al. Non-obese (body mass index< 25 kg/m< sup> 2</sup>) Asian Indians with normal waist circumference have high cardiovascular risk. Nutrition. 2003;19(6):503-9.

Excluded - background

1 Deurenberg P, Deurenberg-Yap M, Guricci S. Asians are different from Caucasians and from each other in their body mass index/body fat per cent relationship. Obes Rev. 2002;3(3):141-6.

2 Kivimaki M, Ferrie JE, Batty GD et al. Optimal form of operationalizing BMI in relation to all-cause and cause-specific mortality: the original Whitehall study. Obesity. 2008;16(8):1926-32.

3 Kumar S, Hanif W, Zaman MJ et al. Lower thresholds for diagnosis and management of obesity in British South Asians. Int J Clin Pract. 2011;65(4):378-9.

4 Lakdawala M, Bhasker A. Report: Asian Consensus Meeting on Metabolic Surgery. Recommendations for the use of Bariatric and Gastrointestinal Metabolic Surgery for Treatment of Obesity and Type II Diabetes Mellitus in the Asian Population: August 9th and 10th, 2008, Trivandrum, India. Obes Surg. 2010;20(7):929-36.

5 Lear SA, Humphries KH, Kohli S et al. The use of BMI and waist circumference as surrogates of body fat differs by ethnicity. Obesity (Silver Spring). 2007;2007(11):2817-24.

6 Lear SA, James PT, Ko GT et al. Appropriateness of waist circumference and waist-to-hip ratio cutoffs for different ethnic groups. European journal of clinical nutrition. 2009;64(1):42-61.

7 Misra A, Wasir JS, Vikram NK. Waist circumference criteria for the diagnosis of abdominal obesity are not applicable uniformly to all populations and ethnic groups. Nutrition. 2005;21(9):969-76.

8 Misra A, Chowbey P, Makkar BM et al. Consensus statement for diagnosis of obesity, abdominal obesity and the metabolic syndrome for Asian Indians and recommendations for physical activity, medical and surgical management. J Assoc Physicians India. 2009;57:163-70.

9 Misra A, Khurana L. Obesity-related non-communicable diseases: South Asians vs White Caucasians. International Journal of Obesity. 2010;35(2):167-87.

10 Moy FM, Atiya AS. Waist circumference as a screening tool for weight management: evaluation using receiver operating characteristic curves for Malay subjects. Asia-Pacific Journal of Public Health. 2003;15(2):99-104.

11 Stevens J, Nowicki EM. Body mass index and mortality in asian populations: implications for obesity cut-points. Nutr Rev. 2003;61(3):104-7.

12 Stevens J. Ethnic-specific revisions of body mass index cutoffs to define overweight and obesity in Asians are not warranted. Int J Obes Relat Metab Disord. 2003;27(11):1297-9.

13 Tillin T, Forouhi NG. Metabolic Syndrome and Ethnicity. In: Byrne CD, Wild SH, editors. The Metabolic Syndrome. 2nd ed. 2011. p. 19-44.

14 Tomlinson B, Deng HB, Thomas GN. Prevalence of obesity amongst Chinese populations revisited. Future Lipidology. 2008;3(2):139-52.

15 WHO expert consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet. 2004;2004(9403):157-63.

16 World Health Organization. Waist circumference and waist-hip ratio: report of a WHO expert consultation. 2012.

Excluded - other

1 Cheng TO. Chinese body mass index is much lower as a risk factor for coronary artery disease. Circulation. 2004;109(14):e184.

2 Joshi P, Islam S, Pais P et al. Risk factors for early myocardial infarction in South Asians compared with individuals in other countries. JAMA. 2007;297(3):286-94.

3 Lakdawala M, Bhasker A. Asian Consensus Meeting on Metabolic Surgery (ACMOMS). Report: Asian Consensus Meeting on Metabolic Surgery. Recommendations for the use of Bariatric and Gastrointestinal Metabolic Surgery for Treatment of Obesity and Type II Diabetes Mellitus in the Asian Population: August 9 th and 10 th, 2008, Trivandrum, India. Obes Surg. 2010;20(7):929-36.

4 Meenakshisundaram R, Agarwal D, Rajendiran C et al. Risk factors for myocardial infarction among low socioeconomic status South Indian population. Diabetology & metabolic syndrome. 2010;2:32.

5 Pednekar MS, Hakama M, Hebert JR et al. Association of body mass index with all-cause and cause-specific mortality: findings from a prospective cohort study in Mumbai (Bombay), India. Int J Epidemiol. 2008;37(3):524-35.

6 Pierce BL, Kalra T, Argos M et al. A prospective study of body mass index and mortality in Bangladesh. Int J Epidemiol. 2010;39(4):1037-45.

7 Rosenthal AD, Jin F, Shu XO et al. Body fat distribution and risk of diabetes among Chinese women. Int J Obes.Relat Metab Disord. 2004;28(4):594-9.

8 Sauvaget C, Ramadas K, Thomas G et al. Body mass index, weight change and mortality risk in a prospective study in India. International journal of epidemiology. 2008;37(5):990-1004.

9 Talaei M, Thomas GN, Marshall T et al. Appropriate cut-off values of waist circumference to predict cardiovascular outcomes: 7-year follow-up in an Iranian population. Intern Med. 2012;51(2):139-46.

10 Yusuf S, Hawken S, +öunpuu S et al. Obesity and the risk of myocardial infarction in 27 000 participants from 52 countries: a case-control study. The Lancet. 2005;366(9497):1640-9.

11 Zabetian A, Hadaegh F, Azizi F et al. Appropriate Cut-off Values of Anthropometric Variables in Predicting a 7.6-year Risk of Cardiovascular Disease in Iranian Adult Population. Journal of Isfahan Medical School. 2009;27(100):600-17.

12 Zheng W, McLerran DF, Rolland B et al. Association between body-mass index and risk of death in more than 1 million Asians. New England Journal of Medicine. 2011;364(8):719-29.

PHASE II

Excluded – population

1 Aekplakorn W, Kosulwat V, Suriyawongpaisal P. Obesity indices and cardiovascular risk factors in Thai adults. Int J Obes (Lond). 2006;30(12):1782-90.

2 Kim JA CCYKS. Cut-off values of visceral fat area and waist circumference: diagnostic criteria for abdominal obesity in a Korean population. J Korean Med Sci. 2006;21(6):1048-53.

3 Oh SW, Shin SA, Yun YH et al. Cut-off point of BMI and obesity-related comorbidities and mortality in middle-aged Koreans. Obes Res. 2004;12(12):2031-40.

Appendix 2 – Excluded studies

Bazian

Excluded – exposure

1 Waisberg R. Metabolic and hormonal studies in South African women of Indian and African origin PhD by publication. 2009. University of the Witwatersrand. Ref Type: Thesis/Dissertation

2 Webb DR, Gray LJ, Khunti K et al. Screening for diabetes using an oral glucose tolerance test within a western multi-ethnic population identifies modifiable cardiovascular risk: the ADDITION-Leicester study. Diabetologia. 2011;54(9):2237-46.

Excluded – outcome

1 Al-Lawati JA, Jousilahti P. Body mass index, waist circumference and waist-to-hip ratio cut-off points for categorisation of obesity among Omani Arabs. Public Health Nutr. 2008;11(1):102-8.

2 Al Kadi HA, Alissa EM. Prevalence of hyperlipidemia and associated risk factors among healthy young Saudi females: relationship with waist Circumference and body Mass Index. Endocrinol Metabol Syndrome. 2011;S:2.

3 Chakraborty R, Bose K, Khongsdier R et al. Body mass index and body fat among adult Bengalee male slum dwellers in West Bengal, India. Obesity Research & Clinical Practice. 2009;3(3):141-8.

4 Chang CJ, Wu CH, Chang CS et al. Low body mass index but high percent body fat in Taiwanese subjects: implications of obesity cutoffs. Int J Obes Relat Metab Disord. 2003;27(2):253-9.

5 Deurenberg P, Yap M, van Staveren WA. Body mass index and percent body fat: a meta analysis among different ethnic groups. Int J Obes Relat Metab Disord. 1998;22(12):1164-71.

6 Dudeja V, Misra A, Pandey RM et al. BMI does not accurately predict overweight in Asian Indians in northern India. Br J Nutr. 2001;86(1):105-12.

7 Gray LJ, Yates T, Davies MJ et al. Defining obesity cut-off points for migrant South Asians. PLoS One. 2011;6(10):e26464.

8 Ibrahim MM, Elamragy AA, Girgis H et al. Cut off values of waist circumference and associated cardiovascular risk in Egyptians. BMC Cardiovasc Disord. 2011;11:53.

9 Mathe N. Adiposity and CVD risk factors: a comparison between ethnicities PhD by publication. 2010.
Ref Type: Thesis/Dissertation

10 Orr-Walker B, Evans MC, Reid IR et al. Increased abdominal fat in young women of Indian origin. Asia Pac J Clin Nutr. 2005;14(1):69-73.

11 Unwin N, Harland J, White M et al. Body mass index, waist circumference, waist-hip ratio, and glucose intolerance in Chinese and Europid adults in Newcastle, UK. J Epidemiol Community Health. 1997;51(2):160-6.

12 Wang JW, Hu DY, Sun YH et al. Obesity criteria for identifying metabolic risks. Asia Pac J Clin Nutr. 2009;18(1):105-13.

Excluded – analysis

1 Ashwell M, Gunn P, Gibson S. Waist-to-height ratio is a better screening tool than waist circumference and BMI for adult cardiometabolic risk factors: systematic review and meta-analysis. Obes Rev. 2012;13(3):275-86.

2 Wen CP, David Cheng TY, Tsai SP et al. Are Asians at greater mortality risks for being overweight than Caucasians? Redefining obesity for Asians. Public Health Nutr. 2009;12(4):497-506.

Excluded – other

1 WHO. The Asia-Pacific perspective: Redefining obesity and its treatment. Geneva: World Health Organisation; 2000. Available from: http://www.wpro.who.int/nutrition/documents/Redefining_obesity/en/index.html.

Excluded – Question 4 relevance

1 Chang HY, Hsu CC, Pan WH et al. Gender differences in trends in diabetes prevalence from 1993 to 2008 in Taiwan. Diabetes research and clinical practice. 2010;90(3):358-64.

2 Chen CC, Wang WS, Chang HY et al. Heterogeneity of body mass index, waist circumference, and waist-to-hip ratio in predicting obesity-related metabolic disorders for Taiwanese aged 35-64 y. Clinical nutrition. 2009;28(5):543-8.

3 Chen G, Liu C, Yao J et al. Overweight, obesity, and their associations with insulin resistance and [beta]-cell function among Chinese: a cross-sectional study in China. Metabolism. 2010;59(12):1823-32.

4 Chen Z, Yang G, Zhou M et al. Body mass index and mortality from ischaemic heart disease in a lean population: 10 year prospective study of 220,000 adult men. Int J Epidemiol. 2006;35(1):141-50.

5 Chen Z, Yang G, Offer A et al. Body mass index and mortality in China: a 15-year prospective study of 220 000 men. Int J Epidemiol. 2012;41(2):472-81.

6 Deurenberg-Yap M, Yian TB, Kai CS et al. Manifestation of cardiovascular risk factors at low levels of body mass index and waist-to-hip ratio in Singaporean Chinese. Asia Pacific Journal of Clinical Nutrition. 1999;8(3):177-83.

7 Dong X, Liu Y, Yang J et al. Efficiency of anthropometric indicators of obesity for identifying cardiovascular risk factors in a Chinese population. Postgraduate Medical Journal. 2011;87(1026):251.

8 Gu JJ, Rafalson L, Zhao GM et al. Anthropometric Measurements for Prediction of Metabolic Risk among Chinese Adults in Pudong New Area of Shanghai. Experimental and clinical endocrinology and diabetes. 2011;119(7):387.

9 He Y, Jiang B, Wang J et al. Body mass index versus the metabolic syndrome in relation to cardiovascular risk in the Chinese elderly. Diabetes Care. 2007.

10 He YH, Jiang GX, Yang Y et al. Obesity and its associations with hypertension and type 2 diabetes among Chinese adults age 40 years and over. Nutrition. 2009;25(11):1143-9.

11 Hsu HS, Liu CS, Pi□ÇÉSunyer FX et al. The associations of different measurements of obesity with cardiovascular risk factors in Chinese. European journal of clinical investigation. 2011;41(4):393-404.

12 Hu D, Xie J, Fu P et al. Central Rather Than Overall Obesity Is Related to Diabetes in the Chinese Population: The InterASIA Study. Obesity. 2007;15(11):2809-16.

13 Huang KC, Lin WY, Lee LT et al. Four anthropometric indices and cardiovascular risk factors in Taiwan. Int J Obes.Relat.Metab.Disord. 2002;26(8):1060-8.

14 Hwang LC, Bai CH, Chen CJ. Prevalence of obesity and metabolic syndrome in Taiwan. J Formos.Med Assoc. 2006;105(8):626-35.

15 Hwu CM, Fuh JL, Hsiao CF et al. Waist circumference predicts metabolic cardiovascular risk in postmenopausal Chinese women. Menopause. 2003;10(1):73.

16 Jia Z, Zhou Y, Liu X et al. Comparison of different anthropometric measures as predictors of diabetes incidence in a Chinese population. Diabetes research and clinical practice. 2011.

17 Ko GT, Liu KH, So WY et al. Cutoff values for central obesity in Chinese based on mesenteric fat thickness. Clinical nutrition. 2009;28(6):679-83.

18 Lear SA, Chen MM, Frohlich JJ et al. The relationship between waist circumference and metabolic risk factors: cohorts of European and Chinese descent. Metabolism. 2002;51(11):1427-32.

19 Li WC, Chen IC, Chang YC et al. Waist-to-height ratio, waist circumference, and body mass index as indices of cardiometabolic risk among 36,642 Taiwanese adults. European Journal of Nutrition. 2011 Call for Evidence [Epub ahead of print];1-9.

20 Lin WY, Lee LT, Chen CY et al. Optimal cut-off values for obesity: using simple anthropometric indices to predict cardiovascular risk factors in Taiwan. Int J Obes.Relat.Metab.Disord. 2002 Call for Evidence [Epub ahead of print];26(9):1232-8.

21 Lin WY, Tsai SL, Albu JB et al. Body mass index and all-cause mortality in a large Chinese cohort. CMAJ. 2011.

22 Odegaard AO, Koh WP, Vazquez G et al. BMI and diabetes risk in Singaporean Chinese. Diabetes Care. 2009;32(6):1104-6.

23 Odegaard AO, Pereira MA, Koh WP et al. BMI, all-cause and cause-specific mortality in Chinese Singaporean men and women: the Singapore Chinese health study. PLoS One. 2010;5(11):e14000.

24 Pan WH, Yeh WT. How to define obesity? Evidence-based multiple action points for public awareness, screening, and treatment: an extension of Asian-Pacific recommendations. Asia Pac.J Clin Nutr. 2008;17(3):370-4.

25 Tsai ACH, Hsiao ML. The association of body mass index (BMI) with all-cause mortality in older Taiwanese: Results of a national cohort study. Archives of Gerontology and Geriatrics. 2011.

26 Tseng CH, Chong CK, Chan TT et al. Optimal anthropometric factor cutoffs for hyperglycemia, hypertension and dyslipidemia for the Taiwanese population. Atherosclerosis. 2010;210(2):585-9.

27 Wildman RP, Gu D, Reynolds K et al. Appropriate body mass index and waist circumference cutoffs for categorization of overweight and central adiposity among Chinese adults. Am J Clin Nutr. 2004;(5):1129-36.

28 Wildman RP, Gu D, Reynolds K et al. Are waist circumference and body mass index independently associated with cardiovascular disease risk in Chinese adults? Am J Clin Nutr. 2005;82(6):1195-202.

29 Xiaodong Y, Shujuan W, Yaru X et al. A clinical follow-up study on the risk of cerebral infarction in Chinese aging overweight and obese population. Obesity Research & Clinical Practice. 2011;5(1):e17-e27.

30 Xin Z, Yuan J, Hua L et al. A simple tool detected diabetes and prediabetes in rural Chinese. Journal of clinical epidemiology. 2010;63(9):1030-5.

31 Ye Y, Bao Y, Hou X et al. Identification of waist circumference cutoffs for abdominal obesity in the Chinese population: a 7.8-year follow-up study in the Shanghai urban area. International Journal of Obesity. 2009;33(9):1058-62.

32 Yeh WT, Chang HY, Yeh CJ et al. Do centrally obese Chinese with normal BMI have increased risk of metabolic disorders? Int J Obes.(Lond.). 2005;29(7):818-25.

33 Yim JY, Kim D, Lim SH et al. Sagittal abdominal diameter is a strong anthropometric measure of visceral adipose tissue in the Asian general population. Diabetes Care. 2010 Call for Evidence [Epub ahead of print];33(12):2665-70.

34 Yu Z, Lin X, Haas JD et al. Obesity related metabolic abnormalities: distribution and geographic differences among middle-aged and older Chinese populations. Preventive medicine. 2009;48(3):272-8.

35 Zhang X, Shu XO, Gao YT et al. Anthropometric predictors of coronary heart disease in Chinese women. Int J Obes.Relat Metab Disord. 2004;28(6):734-40.

36 Zhang X, Shu XO, Chow WH et al. Body mass index at various ages and mortality in Chinese women: impact of potential methodological biases. International Journal of Obesity. 2008;32(7):1130-6.

37 Zhang X, Shu XO, Gao YT et al. General and abdominal adiposity and risk of stroke in Chinese women. Stroke. 2009;40(4):1098-104.

38 Zhou BF. Effect of body mass index on all-cause mortality and incidence of cardiovascular diseases--report for meta-analysis of prospective studies open optimal cut-off points of body mass index in Chinese adults. Biomed Environ Sci. 2002;(3):245-52.

39 Zhou BF. Predictive values of body mass index and waist circumference for risk factors of certain related diseases in Chinese adults--study on optimal cut-off points of body mass index and waist circumference in Chinese adults. Biomed Environ Sci. 2002;(1):83-96.

40 Gu D, He J, Duan X et al. Body weight and mortality among men and women in China. JAMA. 2006;295(7):776-83.

41 He Y, Zhai F, Ma G et al. Abdominal obesity and the prevalence of diabetes and intermediate hyperglycaemia in Chinese adults. Public Health Nutr. 2009;12(8):1078-84.

42 Li G, Chen X, Jang Y et al. Obesity, coronary heart disease risk factors and diabetes in Chinese: an approach to the criteria of obesity in the Chinese population. Obes Rev. 2002;3(3):167-72.

43 Lin WY, Albu J, Liu CS et al. Larger body mass index and waist circumference are associated with lower mortality in Chinese long-term care facility residents. J Am Geriatr Soc. 2010;58(11):2092-8.

44 Pua YH, Ong PH. Anthropometric indices as screening tools for cardiovascular risk factors in Singaporean women. Asia Pac J Clin Nutr. 2005;14(1):74-9.

Appendix 3 – Excluded studies – Chinese (Phase I)

1 Chang HY, Hsu CC, Pan WH et al. Gender differences in trends in diabetes prevalence from 1993 to 2008 in Taiwan. Diabetes research and clinical practice. 2010;90(3):358-64.

2 Chen CC, Wang WS, Chang HY et al. Heterogeneity of body mass index, waist circumference, and waist-to-hip ratio in predicting obesity-related metabolic disorders for Taiwanese aged 35-64 y. Clinical nutrition. 2009;28(5):543-8.

3 Chen G, Liu C, Yao J et al. Overweight, obesity, and their associations with insulin resistance and [beta]-cell function among Chinese: a cross-sectional study in China. Metabolism. 2010;59(12):1823-32.

4 Chen Z, Yang G, Zhou M et al. Body mass index and mortality from ischaemic heart disease in a lean population: 10 year prospective study of 220,000 adult men. Int J Epidemiol. 2006;35(1):141-50.

5 Chen Z, Yang G, Offer A et al. Body mass index and mortality in China: a 15-year prospective study of 220 000 men. Int J Epidemiol. 2012;41(2):472-81.

6 Deurenberg-Yap M, Yian TB, Kai CS et al. Manifestation of cardiovascular risk factors at low levels of body mass index and waist-to-hip ratio in Singaporean Chinese. Asia Pacific Journal of Clinical Nutrition. 1999;8(3):177-83.

7 Dong X, Liu Y, Yang J et al. Efficiency of anthropometric indicators of obesity for identifying cardiovascular risk factors in a Chinese population. Postgraduate Medical Journal. 2011;87(1026):251.

8 Gu JJ, Rafalson L, Zhao GM et al. Anthropometric Measurements for Prediction of Metabolic Risk among Chinese Adults in Pudong New Area of Shanghai. Experimental and clinical endocrinology and diabetes. 2011;119(7):387.

9 He Y, Jiang B, Wang J et al. Body mass index versus the metabolic syndrome in relation to cardiovascular risk in the Chinese elderly. Diabetes Care. 2007.

10 He YH, Jiang GX, Yang Y et al. Obesity and its associations with hypertension and type 2 diabetes among Chinese adults age 40 years and over. Nutrition. 2009;25(11):1143-9.

11 Hsu HS, Liu CS, Pi□ÇÉSunyer FX et al. The associations of different measurements of obesity with cardiovascular risk factors in Chinese. European journal of clinical investigation. 2011;41(4):393-404.

12 Hu D, Xie J, Fu P et al. Central Rather Than Overall Obesity Is Related to Diabetes in the Chinese Population: The InterASIA Study. Obesity. 2007;15(11):2809-16.

13 Huang KC, Lin WY, Lee LT et al. Four anthropometric indices and cardiovascular risk factors in Taiwan. Int J Obes.Relat.Metab.Disord. 2002;26(8):1060-8.

14 Hwang LC, Bai CH, Chen CJ. Prevalence of obesity and metabolic syndrome in Taiwan. J Formos.Med Assoc. 2006;105(8):626-35.

15 Hwu CM, Fuh JL, Hsiao CF et al. Waist circumference predicts metabolic cardiovascular risk in postmenopausal Chinese women. Menopause. 2003;10(1):73.

16 Jia Z, Zhou Y, Liu X et al. Comparison of different anthropometric measures as predictors of diabetes incidence in a Chinese population. Diabetes research and clinical practice. 2011.

17 Ko GT, Liu KH, So WY et al. Cutoff values for central obesity in Chinese based on mesenteric fat thickness. Clinical nutrition. 2009;28(6):679-83.

18 Lear SA, Chen MM, Frohlich JJ et al. The relationship between waist circumference and metabolic risk factors: cohorts of European and Chinese descent. Metabolism. 2002;51(11):1427-32.

19 Li WC, Chen IC, Chang YC et al. Waist-to-height ratio, waist circumference, and body mass index as indices of cardiometabolic risk among 36,642 Taiwanese adults. European Journal of Nutrition. 2011 Call for Evidence [Epub ahead of print];1-9.

20 Lin WY, Lee LT, Chen CY et al. Optimal cut-off values for obesity: using simple anthropometric indices to predict cardiovascular risk factors in Taiwan. Int J Obes.Relat.Metab.Disord. 2002 Call for Evidence [Epub ahead of print];26(9):1232-8.

21 Lin WY, Tsai SL, Albu JB et al. Body mass index and all-cause mortality in a large Chinese cohort. CMAJ. 2011.

22 Odegaard AO, Koh WP, Vazquez G et al. BMI and diabetes risk in Singaporean Chinese. Diabetes Care. 2009;32(6):1104-6.

23 Odegaard AO, Pereira MA, Koh WP et al. BMI, all-cause and cause-specific mortality in Chinese Singaporean men and women: the Singapore Chinese health study. PLoS One. 2010;5(11):e14000.

24 Pan WH, Yeh WT. How to define obesity? Evidence-based multiple action points for public awareness, screening, and treatment: an extension of Asian-Pacific recommendations. Asia Pac.J Clin Nutr. 2008;17(3):370-4.

25 Tsai ACH, Hsiao ML. The association of body mass index (BMI) with all-cause mortality in older Taiwanese: Results of a national cohort study. Archives of Gerontology and Geriatrics. 2011.

26 Tseng CH, Chong CK, Chan TT et al. Optimal anthropometric factor cutoffs for hyperglycemia, hypertension and dyslipidemia for the Taiwanese population. Atherosclerosis. 2010;210(2):585-9.

27 Wildman RP, Gu D, Reynolds K et al. Appropriate body mass index and waist circumference cutoffs for categorization of overweight and central adiposity among Chinese adults. Am J Clin Nutr. 2004;(5):1129-36.

28 Wildman RP, Gu D, Reynolds K et al. Are waist circumference and body mass index independently associated with cardiovascular disease risk in Chinese adults? Am J Clin Nutr. 2005;82(6):1195-202.

29 Xiaodong Y, Shujuan W, Yaru X et al. A clinical follow-up study on the risk of cerebral infarction in Chinese aging overweight and obese population. Obesity Research & Clinical Practice. 2011;5(1):e17-e27.

30 Xin Z, Yuan J, Hua L et al. A simple tool detected diabetes and prediabetes in rural Chinese. Journal of clinical epidemiology. 2010;63(9):1030-5.

31 Ye Y, Bao Y, Hou X et al. Identification of waist circumference cutoffs for abdominal obesity in the Chinese population: a 7.8-year follow-up study in the Shanghai urban area. International Journal of Obesity. 2009;33(9):1058-62.

32 Yeh WT, Chang HY, Yeh CJ et al. Do centrally obese Chinese with normal BMI have increased risk of metabolic disorders? Int J Obes.(Lond.). 2005;29(7):818-25.

33 Yim JY, Kim D, Lim SH et al. Sagittal abdominal diameter is a strong anthropometric measure of visceral adipose tissue in the Asian general population. Diabetes Care. 2010 Call for Evidence [Epub ahead of print];33(12):2665-70.

34 Yu Z, Lin X, Haas JD et al. Obesity related metabolic abnormalities: distribution and geographic differences among middle-aged and older Chinese populations. Preventive medicine. 2009;48(3):272-8.

35 Zhang X, Shu XO, Gao YT et al. Anthropometric predictors of coronary heart disease in Chinese women. Int J Obes.Relat Metab Disord. 2004;28(6):734-40.

36 Zhang X, Shu XO, Chow WH et al. Body mass index at various ages and mortality in Chinese women: impact of potential methodological biases. International Journal of Obesity. 2008;32(7):1130-6.

37 Zhang X, Shu XO, Gao YT et al. General and abdominal adiposity and risk of stroke in Chinese women. Stroke. 2009;40(4):1098-104.

38 Zhou BF. Effect of body mass index on all-cause mortality and incidence of cardiovascular diseases--report for meta-analysis of prospective studies open optimal cut-off points of body mass index in Chinese adults. Biomed Environ Sci. 2002;(3):245-52.

39 Zhou BF. Predictive values of body mass index and waist circumference for risk factors of certain related diseases in Chinese adults--study on optimal cut-off points of body mass index and waist circumference in Chinese adults. Biomed Environ Sci. 2002;(1):83-96.

Bazian

Appendix 4 - Quality Checklists

Diagnostic Checklist

- Almajwal, 2009
- Diaz, 2007
- Ho, 2003
- Jafar, 2006
- Ko, 1999
- Mansour, 2007b
- Mirmiran, 2003
- Mohan, 2007
- Sarrafzadegan, 2010
- Shah, 2009
- Snehalatha, 2003
- Zaher, 2009

Prognostic Checklist

- Sargeant, 2002
- Janghorbani, 2009
- MacKay, 2009
- Mansour, 2007

Association Checklist

- Chiu, 2011
- Hadaegh, 2006
- Hadaegh, 2009
- Stommel, 2010
- Stevens, 2008
- Taylor, 1999
- Thomas, 2004
- Cameron, 2010
- Pan, 2004

Review Checklist

- Huxley, 2008
- Nyamdorj, 2010
- Nyamdorj, 2010b
- Qiao, 2010

Appendix 4 - Quality Checklists

Diagnostic

Study identification *Including author, title, reference, year of publication*				
Guideline topic:	**Review question no:**			
Checklist completed by:				
Circle one option for each question				
Was the spectrum of participants representative of the patients who will receive the test in practice?	Yes	No	Unclear	N/A
Were selection criteria clearly described?	Yes	No	Unclear	N/A
Was the reference standard likely to classify the target condition correctly?	Yes	No	Unclear	N/A
Was the period between performance of the reference standard and the index test short enough to be reasonably sure that the target condition did not change between the two tests?	Yes	No	Unclear	N/A
Did the whole sample or a random selection of the sample receive verification using the reference standard?	Yes	No	Unclear	N/A
Did participants receive the same reference standard regardless of the index test result?	Yes	No	Unclear	N/A
Was the reference standard independent of the index test? (that is, the index test did not form part of the reference standard)	Yes	No	Unclear	N/A
Was the execution of the index test described in sufficient detail to permit its replication?	Yes	No	Unclear	N/A
Was the execution of the reference standard described in sufficient detail to permit its replication?	Yes	No	Unclear	N/A
Were the index test results interpreted without knowledge of the results of the reference standard?	Yes	No	Unclear	N/A
Were the reference standard results interpreted without knowledge of the results of the index test?	Yes	No	Unclear	N/A
Were the same clinical data available when the test results were interpreted as would be available when the test is used in practice?	Yes	No	Unclear	N/A
Were uninterpretable, indeterminate or intermediate test results reported?	Yes	No	Unclear	N/A
Were withdrawals from the study explained?	Yes	No	Unclear	N/A

Adapted from: NICE, The guidelines manual, 2009

Study: Almajwal et al. Performance of body mass index in predicting diabetes and hypertension: A study from the Eastern Province of Saudi Arabia. Ann Saudi Med. 2009; 29(6):437-45. Refid 180.	Question no: 3			
Was the spectrum of participants representative of the patients who will receive the test in practice?	**Yes**	No	Unclear	N/A
Were selection criteria clearly described?	Yes	**No**	Unclear	N/A
Was the reference standard likely to classify the target condition correctly?	Yes	No	**Unclear**	N/A
Was the period between performance of the reference standard and the index test short enough to be reasonably sure that the target condition did not change between the two tests?	Yes	No	**Unclear**	N/A
Did the whole sample or a random selection of the sample receive verification using the reference standard?	**Yes**	No	Unclear	N/A
Did participants receive the same reference standard regardless of the index test result?	Yes	**No**	Unclear	N/A
Was the reference standard independent of the index test? (that is, the index test did not form part of the reference standard)	**Yes**	No	Unclear	N/A
Was the execution of the index test described in sufficient detail to permit its replication?	**Yes**	No	Unclear	N/A
Was the execution of the reference standard described in sufficient detail to permit its replication?	Yes	**No**	Unclear	N/A
Were the index test results interpreted without knowledge of the results of the reference standard?	Yes	No	**Unclear**	N/A
Were the reference standard results interpreted without knowledge of the results of the index test?	Yes	No	**Unclear**	N/A
Were the same clinical data available when the test results were interpreted as would be available when the test is used in practice?	Yes	No	**Unclear**	N/A
Were uninterpretable, indeterminate or intermediate test results reported?	Yes	**No**	Unclear	N/A
Were withdrawals from the study explained?	Yes	**No**	Unclear	N/A
Are the study results internally valid?	++	+	**-**	
Are the study results applicable to the UK?	++	+	**-**	

Study: Diaz VA, Mainous AG, Baker R et al. How does ethnicity affect the association between obesity and diabetes? Diabetic Medicine. 2007; 24:1199-204. Refid 245.	Question no: 3			
Was the spectrum of participants representative of the patients who will receive the test in practice?	**Yes**	No	Unclear	N/A
Were selection criteria clearly described?	Yes	**No**	Unclear	N/A
Was the reference standard likely to classify the target condition correctly?	Yes	No	**Unclear**	N/A
Was the period between performance of the reference standard and the index test short enough to be reasonably sure that the target condition did not change between the two tests?	Yes	No	**Unclear**	N/A
Did the whole sample or a random selection of the sample receive verification using the reference standard?	**Yes**	No	Unclear	N/A
Did participants receive the same reference standard regardless of the index test result?	Yes	**No**	Unclear	N/A
Was the reference standard independent of the index test? (that is, the index test did not form part of the reference standard)	Yes	No	**Unclear**	N/A
Was the execution of the index test described in sufficient detail to permit its replication?	Yes	**No**	Unclear	N/A
Was the execution of the reference standard described in sufficient detail to permit its replication?	Yes	No	**Unclear**	N/A
Were the index test results interpreted without knowledge of the results of the reference standard?	Yes	No	**Unclear**	N/A
Were the reference standard results interpreted without knowledge of the results of the index test?	Yes	No	**Unclear**	N/A
Were the same clinical data available when the test results were interpreted as would be available when the test is used in practice?	**Yes**	No	Unclear	N/A
Were uninterpretable, indeterminate or intermediate test results reported?	Yes	No	**Unclear**	N/A
Were withdrawals from the study explained?	Yes	No	**Unclear**	N/A
Are the study results internally valid?	++	**+**	-	
Are the study results applicable to the UK?	++	**+**	-	

Study: Ho S-Y, Lam T-H, Janus ED. Waist to stature ratio is more strongly associated with cardiovascular risk factors than other simple anthropometric indices. Ann Epidemiol. 2003; 13(10):683-91. Refid 313.	Question no: 3			
Was the spectrum of participants representative of the patients who will receive the test in practice?	Yes	No	**Unclear**	N/A
Were selection criteria clearly described?	Yes	**No**	Unclear	N/A
Was the reference standard likely to classify the target condition correctly?	Yes	**No**	Unclear	N/A
Was the period between performance of the reference standard and the index test short enough to be reasonably sure that the target condition did not change between the two tests?	Yes	No	**Unclear**	N/A
Did the whole sample or a random selection of the sample receive verification using the reference standard?	**Yes**	No	Unclear	N/A
Did participants receive the same reference standard regardless of the index test result?	Yes	**No**	Unclear	N/A
Was the reference standard independent of the index test? (that is, the index test did not form part of the reference standard)	**Yes**	No	Unclear	N/A
Was the execution of the index test described in sufficient detail to permit its replication?	**Yes**	No	Unclear	N/A
Was the execution of the reference standard described in sufficient detail to permit its replication?	Yes	**No**	Unclear	N/A
Were the index test results interpreted without knowledge of the results of the reference standard?	Yes	No	**Unclear**	N/A
Were the reference standard results interpreted without knowledge of the results of the index test?	Yes	No	**Unclear**	N/A
Were the same clinical data available when the test results were interpreted as would be available when the test is used in practice?	**Yes**	No	Unclear	N/A
Were uninterpretable, indeterminate or intermediate test results reported?	Yes	**No**	Unclear	N/A
Were withdrawals from the study explained?	Yes	**No**	Unclear	N/A
Are the study results internally valid?	++	+	**-**	
Are the study results applicable to the UK?	++	+	**-**	

Study: Jafar TH, Chaturvedi N, Pappas G. Prevalence of overweight and obesity and their association with hypertension and diabetes mellitus in an Indo-Asian population. CMAJ. 2006;175(9):1071-7. Refid 316.	Question no: 3			
Was the spectrum of participants representative of the patients who will receive the test in practice?	**Yes**	No	Unclear	N/A
Were selection criteria clearly described?	Yes	**No**	Unclear	N/A
Was the reference standard likely to classify the target condition correctly?	Yes	No	**Unclear**	N/A
Was the period between performance of the reference standard and the index test short enough to be reasonably sure that the target condition did not change between the two tests?	Yes	No	**Unclear**	N/A
Did the whole sample or a random selection of the sample receive verification using the reference standard?	**Yes**	No	Unclear	N/A
Did participants receive the same reference standard regardless of the index test result?	Yes	No	**Unclear**	N/A
Was the reference standard independent of the index test? (that is, the index test did not form part of the reference standard)	**Yes**	No	Unclear	N/A
Was the execution of the index test described in sufficient detail to permit its replication?	Yes	**No**	Unclear	N/A
Was the execution of the reference standard described in sufficient detail to permit its replication?	**Yes**	No	Unclear	N/A
Were the index test results interpreted without knowledge of the results of the reference standard?	Yes	No	**Unclear**	N/A
Were the reference standard results interpreted without knowledge of the results of the index test?	Yes	No	**Unclear**	N/A
Were the same clinical data available when the test results were interpreted as would be available when the test is used in practice?	**Yes**	No	Unclear	N/A
Were uninterpretable, indeterminate or intermediate test results reported?	Yes	No	**Unclear**	N/A
Were withdrawals from the study explained?	Yes	No	**Unclear**	N/A
Are the study results internally valid?	++	**+**	-	
Are the study results applicable to UK?	++	+	**-**	

Study: Ko GTC, Chan JCN, Cockram CS et al. Prediction of hypertension, diabetes, dyslipidaemia or albuminuria using simple anthropometric indexes in Hong Kong Chinese. Int J Obesity. 1999; 23:1136-42. Refid 378	Question no: 3			
Was the spectrum of participants representative of the patients who will receive the test in practice?	Yes	**No**	Unclear	N/A
Were selection criteria clearly described?	Yes	**No**	Unclear	N/A
Was the reference standard likely to classify the target condition correctly?	**Yes**	No	Unclear	N/A
Was the period between performance of the reference standard and the index test short enough to be reasonably sure that the target condition did not change between the two tests?	**Yes**	No	Unclear	N/A
Did the whole sample or a random selection of the sample receive verification using the reference standard?	**Yes**	No	Unclear	N/A
Did participants receive the same reference standard regardless of the index test result?	Yes	No	**Unclear**	N/A
Was the reference standard independent of the index test? (that is, the index test did not form part of the reference standard)	**Yes**	No	Unclear	N/A
Was the execution of the index test described in sufficient detail to permit its replication?	Yes	**No**	Unclear	N/A
Was the execution of the reference standard described in sufficient detail to permit its replication?	Yes	**No**	Unclear	N/A
Were the index test results interpreted without knowledge of the results of the reference standard?	Yes	No	**Unclear**	N/A
Were the reference standard results interpreted without knowledge of the results of the index test?	Yes	No	**Unclear**	N/A
Were the same clinical data available when the test results were interpreted as would be available when the test is used in practice?	**Yes**	No	Unclear	N/A
Were uninterpretable, indeterminate or intermediate test results reported?	Yes	**No**	Unclear	N/A
Were withdrawals from the study explained?	Yes	**No**	Unclear	N/A
Are the study results internally valid?	++	**+**	-	
Are the study results applicable to the UK?	++	+	**-**	

Study: Mansour AA, Al-Jazairi MI. Cut-off values for anthropometric variables that confer increased risk of type 2 diabetes mellitus and hypertension in Iraq. Arch Med Res. 2007; 38:253-8. Refid 263.	Question no: 3			
Was the spectrum of participants representative of the patients who will receive the test in practice?	**Yes**	No	Unclear	N/A
Were selection criteria clearly described?	Yes	**No**	Unclear	N/A
Was the reference standard likely to classify the target condition correctly?	Yes	No	**Unclear**	N/A
Was the period between performance of the reference standard and the index test short enough to be reasonably sure that the target condition did not change between the two tests?	Yes	No	**Unclear**	N/A
Did the whole sample or a random selection of the sample receive verification using the reference standard?	**Yes**	No	Unclear	N/A
Did participants receive the same reference standard regardless of the index test result?	Yes	**No**	Unclear	N/A
Was the reference standard independent of the index test? (that is, the index test did not form part of the reference standard)	**Yes**	No	Unclear	N/A
Was the execution of the index test described in sufficient detail to permit its replication?	Yes	**No**	Unclear	N/A
Was the execution of the reference standard described in sufficient detail to permit its replication?	Yes	**No**	Unclear	N/A
Were the index test results interpreted without knowledge of the results of the reference standard?	Yes	No	**Unclear**	N/A
Were the reference standard results interpreted without knowledge of the results of the index test?	Yes	No	**Unclear**	N/A
Were the same clinical data available when the test results were interpreted as would be available when the test is used in practice?	**Yes**	No	Unclear	N/A
Were uninterpretable, indeterminate or intermediate test results reported?	Yes	**No**	Unclear	N/A
Were withdrawals from the study explained?	Yes	**No**	Unclear	N/A
Are the study results internally valid?	++	**+**	-	
Are the study results applicable to the UK?	++	**+**	-	

Study: Mirmiran P, Esmaillzadeh A, Azizi F. Detection of cardiovascular risk factors by anthropometric measures in Tehranian adults: receiver operating characteristic (ROC) curve analysis. Eur J Clin Nutr. 2004; 58:1110-8. Refid 318	Question no: 3			
Was the spectrum of participants representative of the patients who will receive the test in practice?	**Yes**	No	Unclear	N/A
Were selection criteria clearly described?	Yes	**No**	Unclear	N/A
Was the reference standard likely to classify the target condition correctly?	**Yes**	No	Unclear	N/A
Was the period between performance of the reference standard and the index test short enough to be reasonably sure that the target condition did not change between the two tests?	**Yes**	No	Unclear	N/A
Did the whole sample or a random selection of the sample receive verification using the reference standard?	**Yes**	No	Unclear	N/A
Did participants receive the same reference standard regardless of the index test result?	Yes	No	**Unclear**	N/A
Was the reference standard independent of the index test? (that is, the index test did not form part of the reference standard)	**Yes**	No	Unclear	N/A
Was the execution of the index test described in sufficient detail to permit its replication?	Yes	**No**	Unclear	N/A
Was the execution of the reference standard described in sufficient detail to permit its replication?	**Yes**	No	Unclear	N/A
Were the index test results interpreted without knowledge of the results of the reference standard?	Yes	No	**Unclear**	N/A
Were the reference standard results interpreted without knowledge of the results of the index test?	Yes	No	**Unclear**	N/A
Were the same clinical data available when the test results were interpreted as would be available when the test is used in practice?	**Yes**	No	Unclear	N/A
Were uninterpretable, indeterminate or intermediate test results reported?	Yes	**No**	Unclear	N/A
Were withdrawals from the study explained?	Yes	**No**	Unclear	N/A
Are the study results internally valid?	**++**	+	-	
Are the study results applicable to the UK?	++	**+**	-	

Study: Mohan V, Deepa M, Farooq S et al. Anthropometric cut points for identification of cardiometabolic risk factors in an urban Asian Indian population. Metabolism Clinical and Experimental. 2007; 56:961-8. Refid 380.	Question no: 3			
Was the spectrum of participants representative of the patients who will receive the test in practice?	**Yes**	No	Unclear	N/A
Were selection criteria clearly described?	Yes	**No**	Unclear	N/A
Was the reference standard likely to classify the target condition correctly?	Yes	No	**Unclear**	N/A
Was the period between performance of the reference standard and the index test short enough to be reasonably sure that the target condition did not change between the two tests?	Yes	No	**Unclear**	N/A
Did the whole sample or a random selection of the sample receive verification using the reference standard?	**Yes**	No	Unclear	N/A
Did participants receive the same reference standard regardless of the index test result?	Yes	**No**	Unclear	N/A
Was the reference standard independent of the index test? (that is, the index test did not form part of the reference standard)	**Yes**	No	Unclear	N/A
Was the execution of the index test described in sufficient detail to permit its replication?	**Yes**	No	Unclear	N/A
Was the execution of the reference standard described in sufficient detail to permit its replication?	**Yes**	No	Unclear	N/A
Were the index test results interpreted without knowledge of the results of the reference standard?	Yes	No	**Unclear**	N/A
Were the reference standard results interpreted without knowledge of the results of the index test?	Yes	No	**Unclear**	N/A
Were the same clinical data available when the test results were interpreted as would be available when the test is used in practice?	**Yes**	No	Unclear	N/A
Were uninterpretable, indeterminate or intermediate test results reported?	Yes	**No**	Unclear	N/A
Were withdrawals from the study explained?	Yes	**No**	Unclear	N/A
Are the study results internally valid?	++	**+**	-	
Are the study results applicable to the UK?	++	+	**-**	

Study: Sarrafzadegan N, Kelishadi R, Najafian A et al. Anthropometric indices in association with cardiometabolic risk factors: Findings for the Isfahan Healthy Heart Program. Atherosclerosis Journal. 2010; 5(4):152-62. Refid 322.	Question no: 3			
Was the spectrum of participants representative of the patients who will receive the test in practice?	**Yes**	No	Unclear	N/A
Were selection criteria clearly described?	Yes	**No**	Unclear	N/A
Was the reference standard likely to classify the target condition correctly?	**Yes**	No	Unclear	N/A
Was the period between performance of the reference standard and the index test short enough to be reasonably sure that the target condition did not change between the two tests?	**Yes**	No	Unclear	N/A
Did the whole sample or a random selection of the sample receive verification using the reference standard?	**Yes**	No	Unclear	N/A
Did participants receive the same reference standard regardless of the index test result?	Yes	**No**	Unclear	N/A
Was the reference standard independent of the index test? (that is, the index test did not form part of the reference standard)	**Yes**	No	Unclear	N/A
Was the execution of the index test described in sufficient detail to permit its replication?	**Yes**	No	Unclear	N/A
Was the execution of the reference standard described in sufficient detail to permit its replication?	**Yes**	No	Unclear	N/A
Were the index test results interpreted without knowledge of the results of the reference standard?	Yes	No	**Unclear**	N/A
Were the reference standard results interpreted without knowledge of the results of the index test?	Yes	No	**Unclear**	N/A
Were the same clinical data available when the test results were interpreted as would be available when the test is used in practice?	**Yes**	No	Unclear	N/A
Were uninterpretable, indeterminate or intermediate test results reported?	Yes	**No**	Unclear	N/A
Were withdrawals from the study explained?	Yes	**No**	Unclear	N/A
Are the study results internally valid?	++	**+**	-	
Are the study results applicable to the UK?	++	+	**-**	

Study: Shah A, Bhandary S, Malik SL et al. Waist circumference and waist-hip ratio as predictors of type 2 diabetes mellitus in the Nepalese population of Kavre District. Nepal Med Coll J. 2009; 11(4):261-7. Refid 395.	Question no: 3			
Was the spectrum of participants representative of the patients who will receive the test in practice?	Yes	**No**	Unclear	N/A
Were selection criteria clearly described?	**Yes**	No	Unclear	N/A
Was the reference standard likely to classify the target condition correctly?	**Yes**	No	Unclear	N/A
Was the period between performance of the reference standard and the index test short enough to be reasonably sure that the target condition did not change between the two tests?	Yes	No	**Unclear**	N/A
Did the whole sample or a random selection of the sample receive verification using the reference standard?	Yes	**No**	Unclear	N/A
Did participants receive the same reference standard regardless of the index test result?	Yes	**No**	Unclear	N/A
Was the reference standard independent of the index test? (that is, the index test did not form part of the reference standard)	**Yes**	No	Unclear	N/A
Was the execution of the index test described in sufficient detail to permit its replication?	**Yes**	No	Unclear	N/A
Was the execution of the reference standard described in sufficient detail to permit its replication?	Yes	**No**	Unclear	N/A
Were the index test results interpreted without knowledge of the results of the reference standard?	Yes	No	**Unclear**	N/A
Were the reference standard results interpreted without knowledge of the results of the index test?	Yes	No	**Unclear**	N/A
Were the same clinical data available when the test results were interpreted as would be available when the test is used in practice?	**Yes**	No	Unclear	N/A
Were uninterpretable, indeterminate or intermediate test results reported?	Yes	**No**	Unclear	N/A
Were withdrawals from the study explained?	Yes	**No**	Unclear	N/A
Are the study results internally valid?	++	+	**-**	
Are the study results applicable to the UK?	++	+	**-**	

Study: Snehalatha C, Viswanathan V, Ramachandran A. Cutoff values for normal anthropometric variables in asian Indian adults. Diabetes Care. 2003; 26(5):1380-4. Refid 200.	Question no: 2 & 3			
Was the spectrum of participants representative of the patients who will receive the test in practice?	Yes	**No**	Unclear	N/A
Were selection criteria clearly described?	**Yes**	No	Unclear	N/A
Was the reference standard likely to classify the target condition correctly?	Yes	**No**	Unclear	N/A
Was the period between performance of the reference standard and the index test short enough to be reasonably sure that the target condition did not change between the two tests?	Yes	No	**Unclear**	N/A
Did the whole sample or a random selection of the sample receive verification using the reference standard?	**Yes**	No	Unclear	N/A
Did participants receive the same reference standard regardless of the index test result?	**Yes**	No	Unclear	N/A
Was the reference standard independent of the index test? (that is, the index test did not form part of the reference standard)	**Yes**	No	Unclear	N/A
Was the execution of the index test described in sufficient detail to permit its replication?	Yes	**No**	Unclear	N/A
Was the execution of the reference standard described in sufficient detail to permit its replication?	**Yes**	No	Unclear	N/A
Were the index test results interpreted without knowledge of the results of the reference standard?	Yes	No	**Unclear**	N/A
Were the reference standard results interpreted without knowledge of the results of the index test?	Yes	No	**Unclear**	N/A
Were the same clinical data available when the test results were interpreted as would be available when the test is used in practice?	**Yes**	No	Unclear	N/A
Were uninterpretable, indeterminate or intermediate test results reported?	Yes	**No**	Unclear	N/A
Were withdrawals from the study explained?	Yes	**No**	Unclear	N/A
Are the study results internally valid?	++	+	**-**	
Are the study results applicable to the UK?	++	+	**-**	

Study: Zaher ZMM, Zambari R, Pheng CS et al. Optimal cut-off levels to define obesity: body mass index and waist circumference. Asia Pac J Clin Nutr. 2009; 18(2):209-16. Refid 368.	Question no: 3			
Was the spectrum of participants representative of the patients who will receive the test in practice?	Yes	No	Unclear	N/A
Were selection criteria clearly described?	Yes	No	Unclear	N/A
Was the reference standard likely to classify the target condition correctly?	Yes	No	Unclear	N/A
Was the period between performance of the reference standard and the index test short enough to be reasonably sure that the target condition did not change between the two tests?	Yes	No	Unclear	N/A
Did the whole sample or a random selection of the sample receive verification using the reference standard?	Yes	No	Unclear	N/A
Did participants receive the same reference standard regardless of the index test result?	Yes	No	Unclear	N/A
Was the reference standard independent of the index test? (that is, the index test did not form part of the reference standard)	Yes	No	Unclear	N/A
Was the execution of the index test described in sufficient detail to permit its replication?	Yes	No	Unclear	N/A
Was the execution of the reference standard described in sufficient detail to permit its replication?	Yes	No	Unclear	N/A
Were the index test results interpreted without knowledge of the results of the reference standard?	Yes	No	Unclear	N/A
Were the reference standard results interpreted without knowledge of the results of the index test?	Yes	No	Unclear	N/A
Were the same clinical data available when the test results were interpreted as would be available when the test is used in practice?	Yes	No	Unclear	N/A
Were uninterpretable, indeterminate or intermediate test results reported?	Yes	No	Unclear	N/A
Were withdrawals from the study explained?	Yes	No	Unclear	N/A
Are the study results internally valid?	++	+	-	
Are the study results applicable to the UK?	++	+	-	

Appendix 4 - Quality Checklists

Prognostic

Study identification *Include author, title, reference, year of publication*				
Guideline topic:		**Review question no:**		
Checklist completed by:				
Circle one option for each question				
1.1	The study sample represents the population of interest with regard to key characteristics, sufficient to limit potential bias to the results	Yes	No	Unclear
1.2	Loss to follow-up is unrelated to key characteristics (that is, the study data adequately represent the sample), sufficient to limit potential bias	Yes	No	Unclear
1.3	The prognostic factor of interest is adequately measured in study participants, sufficient to limit potential bias	Yes	No	Unclear
1.4	The outcome of interest is adequately measured in study participants, sufficient to limit bias	Yes	No	Unclear
1.5	Important potential confounders are appropriately accounted for, limiting potential bias with respect to the prognostic factor of interest	Yes	No	Unclear
1.6	The statistical analysis is appropriate for the design of the study, limiting potential for the presentation of invalid results	Yes	No	Unclear

Adapted from: NICE, The guidelines manual, 2009

Study: Janghorbani M, Amini M. Comparison of body mass index with abdominal obesity indicators and waist-to-stature ratio for prediction of type 2 diabetes: The Isfahan diabetes prevention study. Obes Res Clin Pract. 2010; 4:e25-e32. Refid 28.	Question no: 1			
The study sample represents the population of interest with regard to key characteristics, sufficient to limit potential bias to the results	Yes	**No**	Unclear	N/A
Loss to follow-up is unrelated to key characteristics (that is, the study data adequately represent the sample), sufficient to limit potential bias	Yes	No	**Unclear**	N/A
The prognostic factor of interest is adequately measured in study participants, sufficient to limit potential bias	**Yes**	No	Unclear	N/A
The outcome of interest is adequately measured in study participants, sufficient to limit bias	**Yes**	No	Unclear	N/A
Important potential confounders are appropriately accounted for, limiting potential bias with respect to the prognostic factor of interest	Yes	No	**Unclear**	N/A
The statistical analysis is appropriate for the design of the study, limiting potential for the presentation of invalid results	Yes	No	**Unclear**	N/A
Are the study results internally valid?	++	**+**	-	
Are the study results applicable to the UK?	++	+	**-**	

Study: MacKay MF, Haffner SM, Wagenknecht LE et al. Prediction of type 2 diabetes using alternate anthropometric measures in a multi-ethnic cohort. Diabetes Care. 2009; 32(5):956-8. Refid 25.	Question no: 1			
The study sample represents the population of interest with regard to key characteristics, sufficient to limit potential bias to the results	Yes	No	Unclear	N/A
Loss to follow-up is unrelated to key characteristics (that is, the study data adequately represent the sample), sufficient to limit potential bias	Yes	No	Unclear	N/A
The prognostic factor of interest is adequately measured in study participants, sufficient to limit potential bias	Yes	No	Unclear	N/A
The outcome of interest is adequately measured in study participants, sufficient to limit bias	Yes	No	Unclear	N/A
Important potential confounders are appropriately accounted for, limiting potential bias with respect to the prognostic factor of interest	Yes	No	Unclear	N/A
The statistical analysis is appropriate for the design of the study, limiting potential for the presentation of invalid results	Yes	No	Unclear	N/A
Are the study results internally valid?	++	+	-	
Are the study results applicable to the UK?	++	+	-	

Study: Mansour AA, Al-Jazairi MI. Predictors of incident diabetes mellitus in Basrah, Iraq. Ann Nutr Metab. 2007; 51:227-80. Refid 29.	Question no: 1 & 3			
The study sample represents the population of interest with regard to key characteristics, sufficient to limit potential bias to the results	Yes	No	**Unclear**	N/A
Loss to follow-up is unrelated to key characteristics (that is, the study data adequately represent the sample), sufficient to limit potential bias	Yes	No	**Unclear**	N/A
The prognostic factor of interest is adequately measured in study participants, sufficient to limit potential bias	**Yes**	No	Unclear	N/A
The outcome of interest is adequately measured in study participants, sufficient to limit bias	**Yes**	No	Unclear	N/A
Important potential confounders are appropriately accounted for, limiting potential bias with respect to the prognostic factor of interest	Yes	No	**Unclear**	N/A
The statistical analysis is appropriate for the design of the study, limiting potential for the presentation of invalid results	**Yes**	No	Unclear	N/A
Are the study results internally valid?	**++**	+	-	
Are the study results applicable to the UK?	++	**+**	-	

Study Sargeant LA, Bennet FI, Forrester TE et al. Predicting incident diabetes in Jamaica: the role of anthropometry. Obesity. 2002; 10(8):792-8. Refid 31.	Question no: 1 & 3			
The study sample represents the population of interest with regard to key characteristics, sufficient to limit potential bias to the results	Yes	No	**Unclear**	N/A
Loss to follow-up is unrelated to key characteristics (that is, the study data adequately represent the sample), sufficient to limit potential bias	Yes	**No**	Unclear	N/A
The prognostic factor of interest is adequately measured in study participants, sufficient to limit potential bias	Yes	No	**Unclear**	N/A
The outcome of interest is adequately measured in study participants, sufficient to limit bias	Yes	**No**	Unclear	N/A
Important potential confounders are appropriately accounted for, limiting potential bias with respect to the prognostic factor of interest	**Yes**	No	Unclear	N/A
The statistical analysis is appropriate for the design of the study, limiting potential for the presentation of invalid results	**Yes**	No	Unclear	N/A
Are the study results internally valid?	++	**+**	-	
Are the study results applicable to the UK?	++	+	**-**	

Bazian

Association

Study identification (Include full citation details) **Study design:** Refer to the the glossary of study designs (appendix D) and the algorithm for classifying experimental and observational study designs (appendix E) to best describe the paper's underpinning study design **Guidance topic:** **Assessed by**		
Section 1: Population		
1.1 Is the source population or source area well described?	□ ++ □ + □ - □ NR □ NA	**Comments:**
1.2 Is the eligible population or area representative of the source population or area?	□ ++ □ + □ - □ NR □ NA	**Comments:**
1.3 Do the selected participants or areas represent the eligible population or area?	□ ++ □ + □ - □ NR □ NA	**Comments:**
Section 2: Method of selection of exposure (or comparison) group		
2.1 Selection of exposure (and comparison) group. How was selection bias minimised?	□ ++ □ + □ - □ NR □ NA	**Comments:**
2.2 Was the selection of explanatory variables based on a sound theoretical basis?	□ ++ □ + □ - □ NR □ NA	**Comments:**
2.3 Was the contamination acceptably low?	□ ++ □ + □ - □ NR □ NA	**Comments:**
2.4 How well were likely confounding factors identified and controlled?	□ ++ □ + □ - □ NR □ NA	**Comments:**
2.5 Is the setting applicable to the UK?	□ ++ □ + □ - □ NR □ NA	**Comments:**
Section 3: Outcomes		
3.1 Were the outcome measures and procedures reliable?	□ ++ □ + □ - □ NR □ NA	**Comments:**
3.2 Were the outcome measurements complete?	□ ++ □ + □ - □ NR □ NA	**Comments:**

3.3 Were all the important outcomes assessed?	□ ++ □ + □ - □ NR □ NA	**Comments:**
3.3 Were all the important outcomes assessed?	□ ++ □ + □ - □ NR □ NA	**Comments:**
3.5 Was follow-up time meaningful?	□ ++ □ + □ - □ NR □ NA	**Comments:**
Section 4: Analyses		
4.1 Was the study sufficiently powered to detect an intervention effect (if one exists)?	□ ++ □ + □ - □ NR □ NA	**Comments:**
4.2 Were multiple explanatory variables considered in the analyses?	□ ++ □ + □ - □ NR □ NA	**Comments:**
4.3 Were the analytical methods appropriate?	□ ++ □ + □ - □ NR □ NA	**Comments:**
4.6 Was the precision of association given or calculable? Is association meaningful?	□ ++ □ + □ - □ NR □ NA	**Comments:**
Section 5: Summary		
5.1 Are the study results internally valid (i.e. unbiased)?	□ ++ □ + □ -	**Comments:**
5.2 Are the findings generalisable to the source population (i.e. externally valid)?	□ ++ □ + □ -	**Comments:**

Adapted from: NICE, Methods for the development of NICE public heath guidance (second edition), 2009

Study: Chiu M, Austin PC, Manuel DG et al. Deriving ethnic-specific BMI cutoff points for assessing diabetes risk. Diabetes Care. 2011; 34:1741-8. Refid 342.	Question no: 4			
Is the source population or source area well described?	Yes	No	**Unclear**	N/A
Is the eligible population or area representative of the source population or area?	Yes	No	**Unclear**	N/A
Do the selected participants or areas represent the eligible population or area?	**Yes**	No	Unclear	N/A
Were likely confounding factors identified and controlled?	Yes	No	**Unclear**	N/A
Is the setting applicable to the UK?	**Yes**	No	Unclear	N/A
Were the outcome measures and procedures reliable?	Yes	No	**Unclear**	N/A
Were the outcome measures complete?	Yes	No	**Unclear**	N/A
Was follow-up time sufficient?	**Yes**	No	Unclear	N/A
Were multiple explanatory variables considered in the analysis?	**Yes**	No	Unclear	N/A
Were the analytical methods appropriate?	**Yes**	No	Unclear	N/A
Was the precision of the association given or calculable? Is association meaningful?	**Yes**	No	Unclear	N/A
Are the study results internally valid?	++	**+**	-	
Are the study results applicable to the UK?	++	**+**	-	

Study: Hadaegh F, Zabetian A, Harati H, Azizi F. Waist/Height ratio as a better predictor of Type 2 Diabetes compared to body mass index in Tehranian adult men – a 3.6 year prospective study. Exp Clin Endocrinol Diabetes. 2006; 114:310-5. Refid 27.	Question no: 1 & 2			
Is the source population or source area well described?	**Yes**	No	Unclear	N/A
Is the eligible population or area representative of the source population or area?	Yes	No	**Unclear**	N/A
Do the selected participants or areas represent the eligible population or area?	Yes	No	**Unclear**	N/A
Were likely confounding factors identified and controlled?	**Yes**	No	Unclear	N/A
Is the setting applicable to the UK?	Yes	No	**Unclear**	N/A
Were the outcome measures and procedures reliable?	**Yes**	No	Unclear	N/A
Were the outcome measures complete?	**Yes**	No	Unclear	N/A
Was follow-up time sufficient?	**Yes**	No	Unclear	N/A
Were multiple explanatory variables considered in the analysis?	**Yes**	No	Unclear	N/A
Were the analytical methods appropriate?	**Yes**	No	Unclear	N/A
Was the precision of the association given or calculable? Is association meaningful?	**Yes**	No	Unclear	N/A
Are the study results internally valid?	++	**+**	-	
Are the study results applicable to the UK?	++	**+**	-	

Study: Hadaegh F, Shafiee G, Azizi F. Anthropometric predictors of incident type 2 diabetes mellitus in Iranian women. Ann Saudi Med. 2009; 29(3):194-200. Refid 4.	Question no: 1 & 2			
Is the source population or source area well described?	**Yes**	No	Unclear	N/A
Is the eligible population or area representative of the source population or area?	Yes	No	**Unclear**	N/A
Do the selected participants or areas represent the eligible population or area?	Yes	No	**Unclear**	N/A
Were likely confounding factors identified and controlled?	**Yes**	No	Unclear	N/A
Is the setting applicable to the UK?	Yes	No	**Unclear**	N/A
Were the outcome measures and procedures reliable?	**Yes**	No	Unclear	N/A
Were the outcome measures complete?	**Yes**	No	Unclear	N/A
Was follow-up time sufficient?	**Yes**	No	Unclear	N/A
Were multiple explanatory variables considered in the analysis?	**Yes**	No	Unclear	N/A
Were the analytical methods appropriate?	**Yes**	No	Unclear	N/A
Was the precision of the association given or calculable? Is association meaningful?	**Yes**	No	Unclear	N/A
Are the study results internally valid?	++	**+**	-	
Are the study results applicable to the UK?	++	**+**	-	

Study: Stevens J, Truesdale KP, Katz EG et al. Impact of body mass index on incident hypertension and diabetes in Chinese Asians, American Whites and American Blacks. Am J Epidemiol. 2008; 167:1365-74. Refid 202.	Question no: 4			
Is the source population or source area well described?	**Yes**	No	Unclear	N/A
Is the eligible population or area representative of the source population or area?	Yes	No	**Unclear**	N/A
Do the selected participants or areas represent the eligible population or area?	Yes	No	**Unclear**	N/A
Were likely confounding factors identified and controlled?	Yes	No	**Unclear**	N/A
Is the setting applicable to the UK?	**Yes**	No	Unclear	N/A
Were the outcome measures and procedures reliable?	Yes	No	**Unclear**	N/A
Were the outcome measures complete?	**Yes**	No	Unclear	N/A
Was follow-up time sufficient?	Yes	No	Unclear	**N/A**
Were multiple explanatory variables considered in the analysis?	Yes	No	**Unclear**	N/A
Were the analytical methods appropriate?	**Yes**	No	Unclear	N/A
Was the precision of the association given or calculable? Is association meaningful?	Yes	No	**Unclear**	N/A
Are the study results internally valid?	++	**+**	-	
Are the study results applicable to the UK?	++	**+**	-	

Study: Stommel M, Schoenborn CA. Variations in BMI and prevalence of health risks in diverse racial and ethnic populations. Obesity. 2010; 18(9):1821-6. Refid 203.	Question no: 4			
Is the source population or source area well described?	Yes	No	**Unclear**	N/A
Is the eligible population or area representative of the source population or area?	Yes	No	**Unclear**	N/A
Do the selected participants or areas represent the eligible population or area?	Yes	No	**Unclear**	N/A
Were likely confounding factors identified and controlled?	**Yes**	No	Unclear	N/A
Is the setting applicable to the UK?	Yes	No	**Unclear**	N/A
Were the outcome measures and procedures reliable?	Yes	No	**Unclear**	N/A
Were the outcome measures complete?	Yes	No	**Unclear**	N/A
Was follow-up time sufficient?	Yes	No	Unclear	**N/A**
Were multiple explanatory variables considered in the analysis?	**Yes**	No	Unclear	N/A
Were the analytical methods appropriate?	**Yes**	No	Unclear	N/A
Was the precision of the association given or calculable? Is association meaningful?	Yes	**No**	Unclear	N/A
Are the study results internally valid?	++	**+**	-	
Are the study results applicable to the UK?	++	**+**	-	

Study: Taylor HA Jr, Coady SA, Levy D et al. Relationships of BMI to cardiovascular risk factors differ by ethnicity. Obesity. 2009; 18(8): 1638-45. Refid 63.	Question no: 4			
Is the source population or source area well described?	**Yes**	No	Unclear	N/A
Is the eligible population or area representative of the source population or area?	Yes	No	**Unclear**	N/A
Do the selected participants or areas represent the eligible population or area?	Yes	No	**Unclear**	N/A
Were likely confounding factors identified and controlled?	**Yes**	No	Unclear	N/A
Is the setting applicable to the UK?	**Yes**	No	Unclear	N/A
Were the outcome measures and procedures reliable?	**Yes**	No	Unclear	N/A
Were the outcome measures complete?	**Yes**	No	Unclear	N/A
Was follow-up time sufficient?	Yes	No	Unclear	**N/A**
Were multiple explanatory variables considered in the analysis?	Yes	No	**Unclear**	N/A
Were the analytical methods appropriate?	**Yes**	No	Unclear	N/A
Was the precision of the association given or calculable? Is association meaningful?	**Yes**	No	Unclear	N/A
Are the study results internally valid?	**++**	+	-	
Are the study results applicable to the UK?	++	**+**	-	

Study: Thomas GN, Ho S-Y, Lam KSL et al. Impact of obesity and body fat distribuition on cardiovascular risk factors in Hong Kong Chinese. Obesity. 2004; 12(11):1805-13. Refid 328.	Question no: 2			
Is the source population or source area well described?	Yes	No	**Unclear**	N/A
Is the eligible population or area representative of the source population or area?	Yes	No	**Unclear**	N/A
Do the selected participants or areas represent the eligible population or area?	Yes	No	**Unclear**	N/A
Were likely confounding factors identified and controlled?	Yes	**No**	Unclear	N/A
Is the setting applicable to the UK?	Yes	**No**	Unclear	N/A
Were the outcome measures and procedures reliable?	Yes	No	**Unclear**	N/A
Were the outcome measures complete?	**Yes**	No	Unclear	N/A
Was follow-up time sufficient?	Yes	No	Unclear	**N/A**
Were multiple explanatory variables considered in the analysis?	Yes	No	**Unclear**	N/A
Were the analytical methods appropriate?	Yes	No	**Unclear**	N/A
Was the precision of the association given or calculable? Is association meaningful?	**Yes**	No	Unclear	N/A
Are the study results internally valid?	++	**+**	-	
Are the study results applicable to the UK?	++	**+**	-	

Study: Cameron AJ, Sicree RA, Zimmet PZ et al. Cut-points for waist circumference in Europids and South Asians. Obesity. 2010; 18(10):2039-2046. Refid 442.	Question no: 4			
Is the source population or source area well described?	Yes	No	**Unclear**	N/A
Is the eligible population or area representative of the source population or area?	Yes	No	**Unclear**	N/A
Do the selected participants or areas represent the eligible population or area?	Yes	No	**Unclear**	N/A
Were likely confounding factors identified and controlled?	Yes	**No**	Unclear	N/A
Is the setting applicable to the UK?	Yes	No	**Unclear**	N/A
Were the outcome measures and procedures reliable?	**Yes**	No	Unclear	N/A
Were the outcome measures complete?	**Yes**	No	Unclear	N/A
Was follow-up time sufficient?	**Yes**	No	Unclear	N/A
Were multiple explanatory variables considered in the analysis?	**Yes**	No	Unclear	N/A
Were the analytical methods appropriate?	Yes	**No**	Unclear	N/A
Was the precision of the association given or calculable? Is association meaningful?	**Yes**	No	Unclear	N/A
Are the study results internally valid?	++	**+**	-	
Are the study results applicable to the UK?	++	+	**-**	

Study: Pan W-H, Flegal KM, Chang H=Y et al. Body mass intex and obesity-related metabolic disorders in Taiwanese and US whites and blacks: implications for definitions of overweight and obesity for Asians. Am J Clin Nutr. 2004; 79: 31-9. Refid 440.	Question no: 4			
Is the source population or source area well described?	Yes	No	**Unclear**	N/A
Is the eligible population or area representative of the source population or area?	Yes	No	**Unclear**	N/A
Do the selected participants or areas represent the eligible population or area?	Yes	No	**Unclear**	N/A
Were likely confounding factors identified and controlled?	Yes	**No**	Unclear	N/A
Is the setting applicable to the UK?	Yes	No	**Unclear**	N/A
Were the outcome measures and procedures reliable?	**Yes**	No	Unclear	N/A
Were the outcome measures complete?	**Yes**	No	Unclear	N/A
Was follow-up time sufficient?	Yes	No	Unclear	**N/A**
Were multiple explanatory variables considered in the analysis?	**Yes**	No	Unclear	N/A
Were the analytical methods appropriate?	**Yes**	No	Unclear	N/A
Was the precision of the association given or calculable? Is association meaningful?	Yes	**No**	Unclear	N/A
Are the study results internally valid?	++	**+**	-	
Are the study results applicable to the UK?	++	**+**	-	

Study: Stevens J, Juhaeri JC, and Jones DW. The effect of decision rules on the choice of body mass index cutoff for obesity: examples from African American and white women. Am J Clin Nutr. 2002; 75(6):986-92. Refid 441.	Question no: 4			
Is the source population or source area well described?	Yes	No	**Unclear**	N/A
Is the eligible population or area representative of the source population or area?	Yes	No	**Unclear**	N/A
Do the selected participants or areas represent the eligible population or area?	Yes	No	**Unclear**	N/A
Were likely confounding factors identified and controlled?	**Yes**	No	Unclear	N/A
Is the setting applicable to the UK?	**Yes**	No	Unclear	N/A
Were the outcome measures and procedures reliable?	**Yes**	No	Unclear	N/A
Were the outcome measures complete?	**Yes**	No	Unclear	N/A
Was follow-up time sufficient?	**Yes**	No	Unclear	N/A
Were multiple explanatory variables considered in the analysis?	**Yes**	No	Unclear	N/A
Were the analytical methods appropriate?	**Yes**	No	Unclear	N/A
Was the precision of the association given or calculable? Is association meaningful?	Yes	**No**	Unclear	N/A
Are the study results internally valid?	**++**	+	-	
Are the study results applicable to the UK?	++	**+**	-	

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Appendix 4 - Quality Checklists

Reviews

<table>
<tr><td>Study identification
Include author, title, reference, year of publication</td><td colspan="3"></td></tr>
<tr><td>Programme/intervention topic Key question no:</td><td colspan="3"></td></tr>
<tr><td>Checklist completed by:</td><td colspan="3"></td></tr>
<tr><td colspan="4">SCREENING QUESTIONS</td></tr>
<tr><td>In a well-conducted systematic review:</td><td colspan="3">In this review this criterion is met: (Circle one option for each question)</td></tr>
<tr><td>1 Does the review address an appropriate and clearly-focused question that is relevant to one or more of the guidance topic's key research question/s?</td><td>Yes</td><td>No</td><td>Unclear</td></tr>
<tr><td>2 Does the review include the types of study/s relevant to the key research question/s?</td><td>Yes</td><td>No</td><td>Unclear</td></tr>
<tr><td>3 Is the literature search sufficiently rigorous to identify all the relevant studies?</td><td>Yes</td><td>No</td><td>Unclear</td></tr>
<tr><td>4 Is the study quality of included studies appropriately assessed and reported?</td><td>Yes</td><td>No</td><td>Unclear</td></tr>
<tr><td>5 Is an adequate description of the analytical methodology used included, and are the methods used appropriate to the question?</td><td>Yes</td><td>No</td><td>Unclear</td></tr>
</table>

Adapted from: NICE, Methods for the development of NICE public heath guidance (second edition), 2009

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Study: Huxley R, James WPT, Barzi F et al. Ethnic comparisons of the cross-sectional relationships between measures of body size with diabetes and hypertension. Obesity Reviews. 2008; 9(Suppl. 1):53-61. Refid 352.	Question no: 3			
Does the review address an appropriate, relevant and clearly-focused question?	**Yes**	No	Unclear	N/A
Does the review include the types of study/ies relevant to the key research questions?	**Yes**	No	Unclear	N/A
Is the literature search sufficiently rigorous to identify all the relevant studies?	Yes	No	Unclear	**N/A**
Is the study quality of included studies appropriately assessed and reported?	Yes	**No**	Unclear	N/A
Is an adequate description of analytical methodology used included, and are the methods used appropriate to the question?	**Yes**	No	Unclear	N/A
Summary quality score	++	**+**	-	
Are the review results/findings applicable to the UK?	++	**+**	-	

Study: Nyamdorj R. Anthropometric measures of obesity-their association with type 2 diabetes and hypertension across ethnic groups PhD by publication. 2010. Refid 219.	Question no: 3			
Does the review address an appropriate, relevant and clearly-focused question?	**Yes**	No	Unclear	N/A
Does the review include the types of study/ies relevant to the key research questions?	**Yes**	No	Unclear	N/A
Is the literature search sufficiently rigorous to identify all the relevant studies?	Yes	No	Unclear	**N/A**
Is the study quality of included studies appropriately assessed and reported?	Yes	**No**	Unclear	N/A
Is an adequate description of analytical methodology used included, and are the methods used appropriate to the question?	**Yes**	No	Unclear	N/A
Summary quality score	++	**+**	-	
Are the review results/findings applicable to the UK?	++	**+**	-	

Study: Nyamdorj R, Pitkaniemi J, Tuomilehto J et al. Ethnic comparison of the association of undiagnosed diabetes with obesity. Int J Obes (Lond). 2010;34(2):332-9. Refid 403.	Question no: 4			
Does the review address an appropriate, relevant and clearly-focused question?	**Yes**	No	Unclear	N/A
Does the review include the types of study/ies relevant to the key research questions?	**Yes**	No	Unclear	N/A
Is the literature search sufficiently rigorous to identify all the relevant studies?	Yes	No	Unclear	**N/A**
Is the study quality of included studies appropriately assessed and reported?	Yes	**No**	Unclear	N/A
Is an adequate description of analytical methodology used included, and are the methods used appropriate to the question?	**Yes**	No	Unclear	N/A
Summary quality score	++	**+**	-	
Are the review results/findings applicable to the UK?	++	**+**	-	

Study: Qiao Q, Nyamdorj R. The optimal cutoff values and their performance of waist circumference and waist-to-hip ratio for diagnosing type II diabetes. Eur J Clin Nutr. 2010; 64:23-9. Refid 388.	Question no: 3			
Does the review address an appropriate, relevant and clearly-focused question?	Yes	No	Unclear	N/A
Does the review include the types of study/ies relevant to the key research questions?	Yes	No	Unclear	N/A
Is the literature search sufficiently rigorous to identify all the relevant studies?	Yes	No	Unclear	N/A
Is the study quality of included studies appropriately assessed and reported?	Yes	No	Unclear	N/A
Is an adequate description of analytical methodology used included, and are the methods used appropriate to the question?	Yes	No	Unclear	N/A
Summary quality score	++	+	-	
Are the review results/findings applicable to the UK?	++	+	-	

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Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Hadaegh et al, 2006 **Study ID:** Refid 27 **Data source:** Tehran Lipid and Glucose Study **Full Citation:** Hadaegh F, Zabetian A, Harati H, Azizi F. Waist/Height ratio as a better predictor of Type 2 Diabetes compared to body mass index in Tehranian adult men - a 3.6 year prospective study. Exp Clin Endocrinol Diabetes. 2006; 114:310-5. **Sources of funding:** National Research Council of the Islamic Republic of Iran, Shaheed Beheshti University of Medical Sciences **Competing interests:** Not reported	**Study Design:** Cohort **Question/objective:** To identify the best anthropometric index for predicting the development of diabetes **Years of study:** 1999 to 2005 **Mean follow-up:** 3.6 years **Response rate:** 54% **Missing data:** Not reported	**Country trial conducted in:** Iran **Ethnicity:** Middle Eastern **Source of participants:** Population **Number:** 1,852 **Reported eligibility criteria:** Inclusion Male Aged ≥20y Exclusion History of insulin injection History of oral hypoglycaemic drug use Baseline FPG ≥126mg/dL Baseline 2h OGTT ≥200mg/dL	**Gender (% male):** 100% **Age (y), mean (SD):** Total - 45.1 (14.5) Diabetics - 50.8 (13.3) Nondiabetics - 44.8 (14.4) **Baseline BMI (kg/m^2) and WC (cm), mean (SD):** BMI Diabetics - 28.1 (3.8) Nondiabetics - 25.9 (3.9) WC Diabetics - 96.6 (10.2) Nondiabetics - 88.7 (10.8) **Co-morbidity:** Hypertension Diabetics - 40.6% Nondiabetics - 20.6% **Physical disease/health status:** Family history of diabetes Diabetics - 46.4% Nondiabetics - 23.6% Smokers Diabetics - 44.8% Nondiabetics - 36.1%	**Exposure(s)/Index Test:** BMI, WC **Objective exposure measurement/how measured:** Weight measured to nearest 100g in minimal clothing without shoes using digital scales, Height measured with tape meter while standing without shoes, with shoulders in a normal position. Waist circumference measured at the narrowest point. **Outcome(s)/Reference Test:** Diabetes (incident) **Objective outcome measurement/how measured:** Diabetes defined as FPG ≥126mg/dL or 2h OGTT ≥200mg/dL **Other relevant outcomes:** None **Adjustments:** ROC curve analysis adjusted for age. ORs adjusted for age, family history of diabetes, hypertension, total triglycerides, and abnormal glucose tolerance	**Study authors' conclusions:** WSR performs better than BMI in terms of predicting incident type 2 diabetes among Iranian men. **Additional Notes:** Diabetes diagnostic criteria align with current ADA and WHO/IDF criteria. WSR and WHR also assessed; WSR AUC significantly higher than BMI. WSR ORs also significant for second and fourth (highest) quartiles compared to first (lowest) quartile. **Comments on statistical analysis, validity and applicability:** ORs by BMI and WC quartile, with lowest quartile as the reference category. .
Results					
Hadaegh, 2006 **Refid 27** **Iran**	**ROC AUC (95% CI if reported) for BMI**	**OR by BMI (kg/m^2) category, 95% CI (if reported)**	**ROC AUC (95% CI if reported) for WC**	**OR by WC (cm) category, 95% CI (if reported)**	**Other:**
	0.693	**Diabetes (incident)** ≤22.9: 1.0 (reference) 23 - 25.9: 0.6 (0.2 to 1.8) 26 - 27.9: 1.2 (0.4 to 3.2) ≥28: 1.7 (0.7 to 4.0)	Figure only, data not extractable	**Diabetes (incident)** ≤80.9: 1.0 (reference) 81 - 88.9: 2.0 (0.6 to 6.3) 89 - 96.9: 1.2 (0.3 to 3.9) ≥97: 3.0 (1.0 to 8.9)	

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Hadaegh et al, 2009 **Study ID:** Refid 4 **Data source:** Tehran Lipid and Glucose Study **Full Citation:** Hadaegh F, Shafiee G, Azizi F. Anthropometric predictors of incident type 2 diabetes mellitus in Iranian women. Ann Saudi Med. 2009; 29(3):194-200. **Sources of funding:** National Research Council of Islamic Republic of Iran, Shahid Beheshti University of Medical Sciences **Competing interests:** Not reported	**Study Design:** Cohort **Question/objective:** To investigate the ability of anthropometric indices to predict type 2 diabetes in female Iranians **Years of study:** 1999 to 2005 **Median follow-up:** 3.5 years **Response rate:** 60.2% **Missing data:** Subjects with missing data were excluded from the analysis	**Country trial conducted in:** Iran **Ethnicity:** Middle Eastern **Source of participants:** Population **Number:** 2,801 **Reported eligibility criteria:** Inclusion Aged ≥20y Exclusion Diagnosed diabetes	**Gender (% male):** 0% **Age (y), mean (SD):** 45.2 (12.9) **Baseline BMI (kg/m^2) and WC (cm), mean (SD):** <u>BMI</u> Diabetics - 30.3 (4.3) Nondiabetics - 27.4 (5.1) <u>WC</u> Diabetics - 95.9 (9.7) Nondiabetics - 87.2 (12) **Co-morbidity:** <u>Hypertension</u> Diabetics - 41.1% Nondiabetics - 18.9% **Physical disease/health status:** <u>Family History of Diabetes</u> Diabetics - 43% Nondiabetics - 26.9% <u>Smokers</u> Diabetics - 6.1% Nondiabetics - 4.0%	**Exposure(s)/Index Test:** BMI, WC **Objective exposure measurement/how measured:** Weight assessed while minimally clothed without shoes using a digital scale, and recorded to nearest 100 grams. Height assessed in a standing position without shoes using a tape stadiometer. Waist circumference assessed over light clothing at the umbilical level to the nearest 0.1 centimetre. **Outcome(s)/Reference Test:** Diabetes (incident) **Objective outcome measurement/how measured:** Diabetes defined as FPG ≥126mg/dL, or 2h OGTT ≥200mg/dL, or current use of a hypoglycaemic agent. **Other relevant outcomes:** None **Adjustments:** OR adjusted for age, family history of diabetes, hypertension, HDL-C, TG, abnormal glucose tolerance.	**Study authors' conclusions:** The OR of incident diabetes increased across all quartiles of anthropometric indices (p for trend ≤0.05). **Additional Notes:** Urban Iranian population. WSR and WHR also assessed; Both WSR and WHR had significantly increased ORs for the third and fourth quartiles compared to the first quartile. WSR had a significantly higher ROC AUC compared to BMI (0.72 vs. 0.69). WSR was a better predictor of the development of diabetes than BMI Incident diabetes diagnosed according to FPG in 15 subjects, 2h OGTT in 53, by both FPG and 2h OGTT in 19 subjects and by hypoglycaemic agent use in 27 subjects. **Comments on statistical analysis, validity and applicability:** ORs by BMI and WC quartile, with lowest quartile as the reference category.
Results					
Hadaegh, 2009 **Refid 4** **Iran**	**ROC AUC (95% CI if reported) for BMI**	**OR by BMI (kg/m^2) category; 95% CI (if reported)**	**ROC AUC (95% CI if reported) for WC**	**OR by WC (cm); 95% CI (if reported)**	**Other:**
	Diabetes (incident) 0.69	**Diabetes (incident)** 16.2 to 24.4: 1.0 (reference) 24.5 to 27.4: 1.8 (0.7 to 4.5) 27.5 to 30.5: 1.6 (0.6 to 4.0) 30.6 to 48: 3.1 (1.3 to 7.2)	Figure only, data not extractable	**Diabetes (incident)** 58 to 79.9: 1.0 (reference) 80 to 86.9: 2.2 (0.7 to 6.3) 87 to 95.9: 3.7 (1.4 to 9.9) 96 to 130: 3.1 (1.1 to 8.3)	

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Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Sargeant et al, 2002 **Study ID:** Refid 31 **Data source:** Not reported **Full Citation:** Sargeant LA, Bennet FI, Forrester TE et al. Predicting incident diabetes in Jamaica: the role of anthropometry. Obesity. 2002; 10(8):792-8. **Sources of funding:** US National Institutes of Health **Competing interests:** Not reported	**Study Design:** Cohort **Question/objective:** To evaluate the performance of anthropometric indices in predicting incident diabetes, and to identify risk thresholds for the indices **Years of study:** 1993 to 2000 **Mean (SD) follow-up:** 4 (0.5) years **Response rate:** 60% **Missing data:** 408 participants were lost to follow-up (due to death or relocation), 24% of living participants declined a follow-up interview, 63% of living participants were interviewed.	**Country trial conducted in:** Jamaica **Ethnicity:** Black Jamaicans of African ancestry **Source of participants:** Population **Number:** 728 **Reported eligibility criteria:** Inclusion Aged 25 to 74 years Resident of Spanish Town, Jamaica Exclusion Diabetes at baseline Missing data/refusal of follow-up interview	**Gender (% male):** 39.8% **Age (y), mean (SD):** Male - 49.2 (14.9) Female - 45.9 (13.1) **Baseline BMI (kg/m^2) and WC (cm), mean (SD):** <u>BMI</u> Male - 23.5 (4.2) Female - 27.7 (6.5) <u>WC</u> Male - 80.3 (11.7) Female - 82.6 (12.6) **Co-morbidity:** <u>History of hypertension</u> Male - 22.1% Female - 27.0% **Physical disease/health status:** <u>Current drinker</u> Male - 67.6% Female - 21.7% <u>Current smokier</u> Male - 33.5% Female - 11.9%	**Exposure(s)/Index Test:** BMI, WC **Objective exposure measurement/how measured:** Weight and height measured using a "standardized protocol" Waist circumference measured while standing at the smallest point between the ribs and iliac crest **Outcome(s)/Reference Test:** Diabetes **Objective outcome measurement/how measured:** Follow-up FPG ≥7.0mmol/L, or 2h PG ≥11.1mmol/L, or self-reported diagnosis or use of hypoglycaemic agents **Other relevant outcomes:** None **Adjustments:** Stratified by sex	**Study authors' conclusions:** Each of the anthropometric indices were significant predictors of incident diabetes **Additional Notes:** 63% of living participants were interviewed at follow up, with a quarter lost to follow-up due to moving out of the area. Those included in the analysis tended to be younger at baseline compared to those not included. WSR and WHR were also assessed; there were no significant differences in the predictive ability of the four indices (the AUC 95% CIs overlapped for all indices). **Comments on statistical analysis, validity and applicability:** Cutoff values were identified by maximising sensitivity and specificity on the ROC curve. May not be appropriate for deriving WC cutoffs.

Results					
Sargeant, 2002 **Refid 31** **Jamaica**	**ROC AUC (95% CI if reported) for BMI**	**Optimised BMI cutoffs (kg/m^2); S_n and S_p (if reported)**	**ROC AUC (95% CI if reported) for WC**	**Optimised WC cutoffs (cm); S_n and S_p (if reported)**	**Other: HR for 1 unit increase in BMI (kg/m^2) and WC (cm); 95% CI (if reported)**
	Diabetes (incident) Male 0.74 (0.59 to 0.88) Female 0.62 (0.51 to 0.72)	**Diabetes (incident)** Male 24.8 Female 29.3	**Diabetes (incident)** Male 0.78 (0.65 to 0.91) Female 0.61 (0.50 to 0.71)	**Diabetes (incident)** Male 88 Female 84.5	**BMI** HR = 1.08 (1.03 to 1.13) Male HR = 1.20 (1.08 to 1.33) Female HR = 1.05 (0.99 to 1.11) **WC** HR = 1.04 (1.01 to 1.06) Male HR = 1.08 (1.04 to 1.12) Female HR = 1.01 (0.98 to 1.04)

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Chiu et al, 2011 **Study ID:** Refid 342 **Data source:** Statistics Canada's 1996 National Population Health Survey, Canadian Community Health Survey **Full Citation:** Chiu M, Austin PC, Manuel DG et al. Deriving ethnic-specific BMI cutoff points for assessing diabetes risk. Diabetes Care. 2011; 34:1741-8. **Sources of funding:** Heart and Stroke Foundation of Ontario, Canadian Institutes of Health Research, Ontario Ministry of Health and Long-Term Care **Competing interests:** None	**Study Design:** Cohort **Question/objective:** To compare incidence rates of diabetes across different ethnic groups and identify risk-equivalent cutpoints for diabetes risk. **Years of study:** 1996 to 2009 **Mean follow-up:** 6 years **Response rate:** 75.1% to 94.4% (survey response) **Missing data:** Similar across ethnic groups (2.0% to 3.5%)	**Country trial conducted in:** Canada **Ethnicity:** South Asian Black Chinese White **Source of participants:** Population **Number:** 57,210 (total) South Asian - 1,001 Black - 747 Chinese - 866 White - 57,210 **Reported eligibility criteria:** Inclusion Aged ≥30y Ontario, Canada residents White, South Asian, Chinese or Black ethnicity Exclusion Prevalent diabetes, heart disease, stroke, cancer	**Gender (% male):** South Asian - 56.8% Black - 50.1% Chinese - 51.0% White - 49.1% **Age (y), mean (SD):** South Asian - 43.7 Black - 44.5 Chinese - 44.59 White - 48.5 **Baseline BMI (kg/m^2) and WC (cm), mean (SD):** South Asian - 24.6 Black - 26.1 Chinese - 22.6 White - 26.1 **Co-morbidity:** History of hypertension South Asian - 17.1% Black - 20.8% Chinese - 15.2% White - 20.4% **Physical disease/health status:** Current Smoker South Asian - 11.9% Black - 14.9% Chinese - 11.3% White - 26.4% Mean alcoholic drinks/week South Asian - 1.1 Black - 1.3 Chinese - 0.7 White - 3.9 ≤15 min physical activity per day South Asian - 78.8% Black - 70.7% Chinese - 78.9% White - 65.0%	**Exposure(s)/Index Test:** BMI **Objective exposure measurement/how measured:** Self-reported **Outcome(s)/Reference Test:** Diabetes (incident) **Objective outcome measurement/how measured:** Diabetes diagnosis ascertained by the population-based Ontario Diabetes Database **Other relevant outcomes:** None **Adjustments:** Age, sex, BMI-ethnicity interaction, age-BMI interaction, income adequacy, survey year, and urban vs. rural dwelling	**Study authors' conclusions:** There was a strong gradient in risk of incident diabetes with BMI. At BMI ranges thought to confer increasing but acceptable risk among Asian populations (based on WHO Asian specific BMI categories), the incidence of diabetes was significantly higher in South Asian compared to white participants. **Additional Notes:** BMI calculated from self-reported height and weight; may misclassify exposure. **Comments on statistical analysis, validity and applicability:** * based on overlapping CIs, Asians have significantly high incidence of diabetes than whites at all BMI definitions for risk

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Results					
Chiu, 2011 **Refid 342** **Canada**	**Incidence rates per 1,000 person years (95% CI if reported) by BMI category**	**Risk equivalent BMI values (kg/m²) for 30 kg/m² in white subjects**	**HR (95% CI) for incident diabetes compared to Whites**	**Risk equivalent WC values (cm) for European 102 cm and 88 cm**	**Incidence rates per 1,000 person years (95% CI if reported) by other categories**
	Diabetes South Asian <18.5: 1.8 (0.0 to 7.3) 18.5 to <25: 12.1 (7.8 to 16.9)* 25 to <30: 27.7 (17.1 to 38.7)* ≥30: 76.6 (49.0 to 110.3)* 18.5 to <23: 11.6 (6.0 to 17.8)* 23 to <27.5: 20.2 (13.1 to 27.8)* ≥27.5: 44.9 (28.1 to 63.9)* Black <18.5: 0.0 (0.0 to 0.0) 18.5 to <25: 8.4 (3.6 to 14.6) 25 to <30: 18.6 (10.6 to 27.1) ≥30: 38.0 (18.0 to 61.8) 18.5 to <23: 7.3 (1.1 to 16.9) 23 to <27.5: 14.1 (8.6 to 20.2)* ≥27.5: 28.9 (17.0 to 42.9) Chinese <18.5: 0.0 (0.0 to 0.0) 18.5 to <25: 6.8 (3.3 to 10.6) 25 to <30: 19.5 (9.3 to 34.2) ≥30: 79.6 (17.6 to 157.7) 18.5 to <23: 3.7 (1.1 to 6.4) 23 to <27.5: 16.8 (8.4 to 25.2)* ≥27.5: 30.9 (10.9 to 52.6)* White <18.5: 3.3 (1.2 to 5.6) 18.5 to <25: 4.1 (3.7 to 4.5) 25 to <30: 10.0 (9.3 to 10.8) ≥30: 25.6 (23.5 to 27.4) 18.5 to <23: 3.1 (2.7 to 3.6) 23 to <27.5: 6.9 (6.4 to 7.6) ≥27.5: 19.0 (17.9 to 20.0)	**Diabetes** White: 30 Black: 26 Chinese: 25 South Asian: 24	**Adjusted for age** Overall South Asian - 2.63 (1.99 to 3.27) Black - 2.04 (1.50 to 2.68) Chinese - 1.15 (0.73 to 1.68) White - 1.0 (reference) Male South Asian - 2.73 (1.83 to 3.69) Black - 1.53 (0.89 to 2.23) Chinese - 1.11 (0.61 to 1.78) White - 1.0 (reference) Female South Asian - 2.48 (1.62 to 3.42) Black - 2.75 (1.71 to 3.94) Chinese - 1.19 (0.53 to 1.89) White - 1.0 (reference) **Adjusted for BMI** South Asian - 3.40 (2.58 to 4.24) Black - 1.99 (1.39 to 2.71 Chinese - 1.87 (1.16 to 2.60) White - 1.0 (reference) Male South Asian - 3.78 (2.59 to 5.08) Black - 1.65 (0.87 to 2.56) Chinese - 1.76 (0.97 to 2.83) White - 1.0 (reference) Female South Asian - 3.01 (1.99 to 4.20) Black - 2.40 (1.47 to 3.52) Chinese - 2.00 (0.88 to 3.18) White - 1.0 (reference)	N/A	**Diabetes** Non-immigrant South Asian - 30.8 (3.4 to 79.5) Black - 8.1 (0.7 to 19.4) Chinese - 8.6 (0.9 to 21.7) White - 8.9 (8.5 to 9.4) Immigrant South Asian - 20.5 (15.9 to 25.1) Black - 17.2 (12.7 to 22.8) Chinese - 9.4 (5.8 to 13.5) White - 11.7 (10.4 to 13.0) <10y in Canada South Asian - 17.5 (11.3 to 25.5) Black - 14.3 (5.5 to 26.2) Chinese - 2.6 (0.7 to 5.0) White - 4.0 (2.2 to 6.4) 10y to <30y in Canada South Asian - 22.6 (14.8 to 30.2) Black - 17.4 (10.7 to 25.3) Chinese - 10.7 (5.4 to 16.6) White - 8.9 (6.8 to 11.0) ≥30y in Canada South Asian - 23.8 (10.1 to 41.8) Black - 19.4 (8.5 to 34.3) Chinese - 29.9 (8.8 to 57.4) White - 14.9 (13.2 to 16.7)

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Janghorbani et al, 2009 **Study ID:** Refid 28 **Data source:** Isfahan Diabetes Prevention Study **Full Citation:** Janghorbani M, Amini M. Comparison of body mass index with abdominal obesity indicators and waist-to-stature ratio for prediction of type 2 diabetes: The Isfahan diabetes prevention study. Obes Res Clin Pract. 2010; 4:e25-e32. **Sources of funding:** Not reported **Competing interests:** None	**Study Design:** Cohort **Question/objective:** To compared the ability of BMI, WC, WHR and WSR to predict progression to diabetes in non-diabetic relatives of diabetes patients **Years of study:** 2003 to 2008 **Mean follow-up:** 2.3 years **Response rate:** Not reported **Missing data:** Not reported	**Country trial conducted in:** Iran **Ethnicity:** Middle Eastern **Source of participants:** Clinic **Number:** 704 **Reported eligibility criteria:** Inclusion Aged between 20 and 70 years old in 2003-2005 Non-diabetics ≥1 post-baseline examination Exclusion Pregnant women	**Gender (% male):** 21.4% **Age (y), mean (SD):** 42.7 (6.4) **Baseline BMI (kg/m^2) and WC (cm), mean (SD):** BMI Developed diabetes - 30.9 (0.48) Did not develop diabetes - 28.9 (0.16) WC Developed diabetes - 92.0 (1.04) Did not develop diabetes - 88.3 (0.35) **Co-morbidity:** Not reported **Physical disease/health status:** Not reported	**Exposure(s)/Index Test:** BMI, WC **Objective exposure measurement/how measured:** Height and weight assessed in light clothing and no shoes. Weight was measured to the nearest 0.1kg on a calibrated beam scale; height was measured to the nearest 0.5cm. Waist circumference was measured to the nearest 0.5cm midway between the lower rib margin and iliac crest after expiration. **Outcome(s)/Reference Test:** Diabetes (incident) **Objective outcome measurement/how measured:** 75 g 2h OGTT ≥200mg/dL (11.1mmol/L), 2 readings of FPG ≥126mg/dL (7.0mmol/L) 1 reading of ≥200mg/dL (11.1mmol/L), Pharmacological treatment for diabetes **Other relevant outcomes:** None **Adjustments:** None	**Study authors' conclusions:** BMI and WC demonstrate similar discriminatory ability in terms of diabetes prediction as WSR. **Additional Notes:** Participants all had a first degree relative with diagnosed diabetes. WSR and WHR also assessed; No significant differences were found between the AUCs for the four measures. **Comments on statistical analysis, validity and applicability:**

Results					
Janghorbani, 2010 **Refid 28** **Iran**	**ROC AUC (95% CI if reported) for BMI**	**RR by BMI (kg/m^2) category; 95% CI (if reported)**	**ROC AUC (95% CI if reported) for WC**	**RR by WC (cm) category; 95% CI (if reported)**	**Other:**
	Diabetes (incident) 0.625 (0.556 to 0.693)	**Diabetes (incident)** <26.2 - 1.00 (reference) 26.2-28.6 - 1.35 (0.60 to 3.03) 28.7-31.5 - 1.84 (0.85 to 3.92) >31.5 - 2.4 (1.16 to 5.19)	**Diabetes (incident)** 0.620 (0.557 to 0.683)	**Diabetes (incident)** <82.0 - 1.00 (reference) 82.0-88.5 - 2.42 (1.03 to 5.70) 88.5-94.5 - 3.06 (1.29 to 7.25) >94.5 - 4.22 (1.81 to 9.86)	**Incidence (per year) of diabetes (95% CI if reported) by BMI** <26.2 - 2.6% 26.2-28.6 - 3.8% 28.7-31.5 - 5.0% >31.5 - 6.6% Incidence (per year) of diabetes (95% CI if reported) by WC (cm) <82.0 - 1.8% 82.0-88.5 - 4.7% 88.5-94.5 - 5.1% >94.5 - 6.6%

Bazian

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: MacKay et al, 2009 **Study ID:** Refid 5 **Data source:** Insulin Resistance Atherosclerosis Study **Full Citation:** MacKay MF, Haffner SM, Wagenknecht LE et al. Prediction of type 2 diabetes using alternate anthropometric measures in a multi-ethnic cohort. Diabetes Care. 2009; 32(5):956-8. **Sources of funding:** US National Institutes of Health **Competing interests:** None	**Study Design:** Cohort **Question/objective:** To compare various anthropometric indices in terms of their diabetes predictive power and to determine whether the predictive ability was modified by ethnicity **Years of study:** 1992 **Mean follow-up:** 5.2 years **Response rate:** Not reported **Missing data:** Not reported	**Country trial conducted in:** USA **Ethnicity:** African American Non-Hispanic White **Source of participants:** Not reported **Number:** 1,073 (total) African American - 282 Non-Hispanic White - 430 Non-scoped (Hispanic) - 361 **Reported eligibility criteria:** Inclusion Aged 40 to 69 years at baseline Exclusion Diabetics	**Gender (% male):** 44% **Age (y), mean (SD):** Not reported **Baseline BMI (kg/m^2) and WC (cm), mean (SD):** Not reported **Co-morbidity:** Not reported **Physical disease/health status:** Not reported	**Exposure(s)/Index Test:** BMI, WC **Objective exposure measurement/how measured:** Not reported **Outcome(s)/Reference Test:** Diabetes (incident) **Objective outcome measurement/how measured:** 2h OGTT, defined using 1999 WHO criteria **Other relevant outcomes:** None **Adjustments:** Adjusted for age, sex; stratified for ethnicity	**Study authors' conclusions:** In non-hispanic whites, BMI was most predictive of diabetes. In African-Americans, the ratio of subscapular to tricep skinfold thickness, which is used to determine the ratio of central to peripheral body fat, was most predictive of diabetes. **Additional Notes:** WSR, WHR, sum of skinfold thickness, ratio of subscapular to tricep thickness and % body fat also measured; WSR had the highest ROC AUC (0.678), followed by BMI (ROC AUC 0.674) for the full cohort. Height, weight and waist circumference reported to be measured using a standardised protocol, the details of which were not reported. **Comments on statistical analysis, validity and applicability:**

Results					
MacKay, 2009 **Refid 5** **USA**	**ROC AUC (95% CI if reported) for BMI**	**OR by BMI (kg/m^2) category; 95% CI (if reported)**	**ROC AUC (95% CI if reported) for WC**	**OR by WC (cm); 95% CI (if reported)**	**Other:**
	Total Cohort - 0.674 African Americans - 0.616 Non-Hispanic Whites - 0.734	N/A	Total Cohort - 0.667 African Americans - 0.630 Non-Hispanic Whites - 0.716	N/A	**OR per 1 SD change in the natural log of BMI** Total Cohort - 1.76 (1.47 to 2.10) African Americans - 1.46 (1.04 to 2.03) Non-Hispanic Whites - 2.22 (1.63 to 3.02) **OR per 1 SD change in the natural log of WC** Total Cohort - 1.75 (1.45 to 2.12) African Americans - 1.51 (1.08 to 2.11) Non-Hispanic Whites - 2.25 (1.59 to 3.17)

Bazian

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Mansour et al, 2007 **Study ID:** Refid 29 **Data source:** Not reported **Full Citation:** Mansour AA, Al-Jazairi MI. Predictors of incident diabetes mellitus in Basrah, Iraq. Ann Nutr Metab. 2007; 51:277-80. **Sources of funding:** Not reported **Competing interests:** Not reported	**Study Design:** Cohort **Question/objective:** To examine the performance of anthropometric indices for predicting incident type 2 diabetes mellitus in Iraqi adults. **Years of study:** 2001 to 2006 **Mean follow-up:** 5 years **Response rate:** Not reported **Missing data:** Not reported	**Country trial conducted in:** Iraq **Ethnicity:** Middle Eastern **Source of participants:** Population **Number:** 13,730 **Reported eligibility criteria:** Inclusion Aged ≥18y Abu al-Khasib district residents Exclusion Prevalent diabetes Pregnancy	**Gender (% male):** 51.7% **Age (y), mean (SD):** 44.9 (15.80) **Baseline BMI (kg/m^2) and WC (cm), mean (SD):** **BMI** 26.20 (5.92) **WC** 91.0 (14.80) **Co-morbidity:** History of hypertension - 13.9% History of stroke - 1.73% History of IHD - 3.08% **Physical disease/health status:** Smoker - 23.0%	**Exposure(s)/Index Test:** BMI, WC **Objective exposure measurement/how measured:** Height and weight assessed in lightweight clothing and no shoes. Height recorded to the nearest centimetre and weight to the nearest 0.5kg. Waist circumference assessed at the umbilical level while breathing normally. **Outcome(s)/Reference Test:** Diabetes (incident) **Objective outcome measurement/how measured:** Diabetes defined as FPG≥126mg/dL (7.0mmol/L) on two occasions, or Symptoms of diabetes and a casual PG ≥200mg/dL (11.1mmol/L) **Other relevant outcomes:** None **Adjustments:** Stratified by sex	**Study authors' conclusions:** All anthropometric indices were higher among patients with incident diabetes compared to those without. WHR had the strongest association with incident diabetes, followed by WC then BMI. **Additional Notes:** WHR and WSR also assessed; no significant differences in ROC AUC compared to WC for males or females. Both measures had significantly higher ROC AUCs compared to BMI in males and females **Comments on statistical analysis, validity and applicability:** Optimal cutoff values identified during ROC analysis by maximising sensitivity and specificity. May not be appropriate for deriving WC cutoffs.
Results					
Mansour, 2007 **Refid 29** **Iraq**	**ROC AUC (95% CI if reported) for BMI**	**Optimised BMI cutoffs (kg/m^2); S_n and S_p (if reported)**	**ROC AUC (95% CI if reported) for WC**	**Optimised WC cutoffs (cm); S_n and S_p (if reported)**	**Other:**
	Diabetes (incident) <u>Males</u> 0.66 (0.64 to 0.68) <u>Females</u> 0.61 (0.59 to 0.64)	**Diabetes (incident)** <u>Males</u> 24.7 <u>Females</u> 26.3	**Diabetes (incident)** <u>Males</u> 0.71 (0.69 to 0.73) <u>Females</u> 0.69 (0.66 to 0.71)	**Diabetes (incident)** <u>Males</u> 90.5 <u>Females</u> 92.5	

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Mohan et al, 2007 **Study ID:** Refid 380 **Data source:** Chennai Urban Rural Epidemiology Study **Full Citation:** Mohan V, Deepa M, Farooq S et al. Anthropometric cut points for identification of cardiometabolic risk factors in an urban Asian Indian population. Metabolism Clinical and Experimental. 2007; 56:961-8. **Sources of funding:** Chennai Willingdon Corporate Foundation **Competing interests:** Not reported	**Study Design:** Cross sectional **Question/objective:** To determine the anthropometric cut points for risk of cardiometabolic risk factors (including diabetes) in urban Asian Indians **Years of study:** Not reported **Response rate:** 90.4% **Missing data:** Not reported	**Country trial conducted in:** India **Ethnicity:** South Asian Indian **Source of participants:** Community **Number:** 2,600 **Reported eligibility criteria:** Inclusion Age ≥20y	**Gender (% male):** Not reported **Age (y) mean:** Not reported **Mean baseline BMI (kg/m^2) and WC (cm):** Male BMI – 22.6 WC – 85.4 Female BMI – 23.1 WC – 81.7 **Co-morbidity:** Not reported **Physical disease/health status:** Not reported	**Exposure(s)/Index Test:** BMI, WC **Objective exposure measurement/how measured:** Height measured with a tape to nearest centimetre, Weight measured with a spring balance on a firm horizontal surface, WC measured at the smallest horizontal girth between the costal margin and iliac crest in subjects wearing one layer of clothing **Outcome(s)/Reference Test:** Diabetes (prevalent) **Objective outcome measurement/how measured:** Two hour postload (75g glucose) plasma glucose ≥200mg/dL (≥11.1mmol/L), Self-report, diabetic under physician care **Other relevant outcomes:** None **Adjustments:** Stratified by sex	**Study authors' conclusions:** The data suggest that a BMI of 23 kg/m^2 and WC of 87 cm for men and 82 cm for women is the most appropriate cut point. **Additional Notes:** Diabetes was assessed in part by self-report; self-report diabetics received a fasting plasma glucose test, however, whether recorded disease status was changed based on the results of this test were not reported. Reported thresholds for diagnosis of diabetes consistent with WHO guidelines. **Comments on statistical analysis, validity and applicability:** Two different methods were used to identify optimum BMI and WC cutoff values: shortest distance on the ROC curve $[=\surd(1-S_n)^2 - (1-S_p)^2]$ and convergence of sensitivity and specificity. Cutoffs identified using these two measures were slightly different (males BMI: 22 vs. 23.1; males WC: 87 vs. 88.2; females BMI: 23 vs. 23.8; females WC: 83 vs. 83.8) No information provided relating to ROC analysis adjustments; Unclear whether results are crude or adjusted.

Results					
Mohan, 2007 **Refid 380** **India**	**ROC AUC (95% CI if reported) for BMI**	**Optimised BMI cutoffs (kg/m^2); S_n and S_p (if reported)**	**ROC AUC (95% CI if reported) for WC**	**Optimised WC cutoffs (cm); S_n and S_p (if reported)**	**Other:**
	Diabetes (prevalent) Male 0.64 (0.61 to 0.67) Female 0.65 (0.63 to 0.68)	**Diabetes (prevalent)** Male BMI - 22 S_n - 77.7% S_p - 47.7% Distance on ROC - 0.57 Female BMI - 23 S_n - 72.0% S_p - 53.6% Distance on ROC - 0.54 **BMI cutoff values (S_n, S_p and distance on ROC) BMI** Male 20 (93.9%, 30.5%, 0.698) 21 (85.3%, 40.4%, 0.614) 22 (77.7%, 47.7%, 0.569) 23 (61.4%, 57.5%, 0.574) 24 (45.2%, 67.4%, 0.638) 25 (32.5%, 77.4%, 0.712) 26 (21.8%, 83.7%, 0.799) 27 (14.2%, 89.4%, 0.865) Female 20 (94.0%, 26.6%, 0.736) 21 (89.3%, 34.5%, 0.664) 22 (79.2%, 43.5%, 0.602) 23 (72.0%, 53.6%, 0.542) 24 (57.7%, 62.1%, 0.568) 25 (44.6%, 71.4%, 0.623) 26 (32.7%, 79.7%, 0.703) 27 (20.8%, 86.5%, 0.803)	**Diabetes (prevalent)** Male 0.67 (0.64 to 0.70) Female 0.67 (0.65 to 0.70)	**Diabetes (prevalent)** Male WC - 87 S_n - 68.7% S_p - 58.0% Distance on ROC - 0.52 Female WC - 83 S_n - 64.6% S_p - 60.1% Distance on ROC - 0.53 **WC cutoff values (S_n, S_p and distance on ROC) BMI** Male 81 (88.7%, 39.1%, 0.619) 82 (86.7%, 41.3%, 0.602) 83 (83.6%, 43.5%, 0.588) 84 (79.5%, 47.0%, 0.568) 85 (75.4%, 50.9%, 0.549) 86 (72.8%, 54.5%, 0.530) 87 (68.7%, 58.0%, 0.524) 88 (63.1%, 61.4%, 0.534) 89 (55.4%, 64.5%, 0.570) 90 (49.2%, 67.2%, 0.605) Female 76 (92.1%, 35.4%, 0.651) 77 (87.2%, 38.9%, 0.624) 78 (84.1%, 41.9%, 0.602) 79 (81.1%, 44.7%, 0.584) 80 (79.9%, 48.2%, 0.556) 81 (75.6%, 51.6%, 0.542) 82 (70.1%, 55.6%, 0.535) 83 (64.6%, 60.1%, 0.533) 84 (56.1%, 63.5%, 0.571) 85 (53.7%, 66.8%, 0.570)	**S_n and S_p for current WHO Asia Pacific BMI (kg/m^2) and WC (cm) cutoff values** Males BMI - 25 S_n - 32.5% S_p - 77.4% WC - 90 S_n - 49.2% S_p - 67.2% Females BMI - 25 S_n - 44.6% S_p - 71.4% WC - 80 S_n - 79.9% S_p - 48.2% **Cutoffs determined by S_n = S_p** Male BMI - 23.1 S_n - 59.4% S_p - 58.3% Female BMI - 23.8 S_n - 60.1% S_p - 59.9% **Cutoffs determined by S_n = S_p** Male WC - 88.2 S_n - 62.1% S_p - 61.8% Female BMI - 83.8 S_n - 61.6% S_p - 60.7%

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Snehalatha et al, 2003 **Study ID:** Refid 200 **Data source:** Not reported **Full Citation:** Snehalatha C, Viswanathan V, Ramachandran A. Cutoff values for normal anthropometric variables in asian Indian adults. Diabetes Care. 2003; 26(5):1380-4. **Sources of funding:** Novo Nordisk Education Foundation **Competing interests:** Not reported	**Study Design:** Cross sectional **Question/objective:** To identify normal cutoff values for BMI, WC and WHR. **Years of study:** Not reported **Response rate:** Not reported **Missing data:** Not reported	**Country trial conducted in:** India **Ethnicity:** South Asian Indian **Source of participants:** Community **Number:** 10,025 **Reported eligibility criteria:** Inclusion Aged ≥20y Resident of one of six Indian cities Exclusion Diabetics	**Gender (% male):** 47.0% **Age (y), mean (SD):** 40.4 (14.2) **Baseline BMI (kg/m^2) and WC (cm), mean (SD):** **BMI** Male - 22.4 (4.2) Female - 23.6 (4.9) **WC** Male - 80.7 (12.2) Female - 79 (13) **Co-morbidity:** Not reported **Physical disease/health status:** Not reported	**Exposure(s)/Index Test:** BMI, WC **Objective exposure measurement/how measured:** Not reported **Outcome(s)/Reference Test:** Diabetes (prevalent) **Objective outcome measurement/how measured:** FPG ≥126mg/dL, or 2h BG ≥200mg/dL **Other relevant outcomes:** None **Adjustments:** Regression analysis and OR stratified by sex, adjusted for age. BMI was stratified into two unit categories, and WC was stratified into five unit categories.	**Study authors' conclusions:** A healthy BMI for both male and female urban Indians is <23kg/m^2; healthy WC for male urban Indians is <85cm, and for female urban Indians <80cm. **Additional Notes:** Sample of Indian urban adults Glucose was assessed using capillary and not venous blood samples. WHR also assessed; cutoff value (S_n, S_p) of 0.89 (78.2%, 49.1%) for males and 0.81 (85.4%, 34.9%) for females. **Comments on statistical analysis, validity and applicability:** BMI and WC were stratified into 2-unit and 5-unit categories. The upper limit of the stratum above which a significant association with diabetes occurred (at p<0.05) was taken to be the cutoff for a normal BMI or WC. Method for identifying optimal BMI and WC values in ROC curve analysis were not specified; reported as "extrapolated from the curves." Statistical analysis excluded known diabetics; this may not accurately reflect the optimal cutoff values for prevalent diabetes.

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Results					
Snehalatha, 2003 **Refid 200** **India**	**OR by BMI (kg/m^2) category, 95% CI (if reported)**	**Optimised BMI cutoffs (kg/m^2); S_n and S_p (if reported)**	**OR by WC (cm) category, 95% CI (if reported)**	**Optimised WC cutoffs (cm); S_n and S_p (if reported)**	**Other:**
	Diabetes (prevalent) Male ≤19.9: 1 (reference) ≥20 to 21: 1.55 >21 to 22: 1.69 >22 to 23: 1.55 >23 to 24: 2.27 (1.29 to 3.99)* >24 to 25: 3.55* >25: 5.47* Female ≤19.9: 1 (reference) ≥20 to 21: 2.17 >21 to 22: 1.06 >22 to 23: 1.27 >23 to 24: 2.03 (1.19 to 3.46)** >24 to 25: 2.67** >25: 2.88** *p<0.005 **p<0.009	**Diabetes (prevalent)** Male - 23 (67.1%, 62.7%) Female - 23 (66.8%, 52.9%)	**Diabetes (prevalent)** Male <70: 1 (reference) ≥70 to 75: 0.7 >75 to 80: 0.77 >80 to 85: 1.29 >85 to 90: 1.98 (1.27 to 3.1)* >90 to 95: 2.99* >95 to 100: 1.54 >100: 5.66* Female <70: 1 (reference) ≥70 to 75: 1.07 >75 to 80: 1.5 >80 to 85: 1.8 (1.12 to 2.83)** >85 to 90: 2.2** >90 to 95: 2.9** >95 to 100: 3.9** >100: 3.7** *p<0.003 **p<0.01	**Diabetes (prevalent)** Male - 85 (63.7%, 67.1%) Female - 80 (69.7%, 56.4%)	

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Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Thomas et al, 2004 **Study ID:** Refid 328 **Data source:** Hong Kong Cardiovascular Risk Factor Prevalence Study **Full Citation:** Thomas GN, Ho S-Y, Lam KSL et al. Impact of obesity and body fat distribuition on cardiovascular risk factors in Hong Kong Chinese. Obesity. 2004; 12(11):1805-13. Sources of funding: Hong Kong Health Services Research Committee, Hong Kong Research Grants Council, Hong Kong Society for the Aged, and University of Hong Kong Committee on Research and Conference Grants **Competing interests:** Not reported	**Study Design:** Cross sectional **Question/objective:** To identify the associations between general and central obesity and cardiovascular risk factors (including diabetes) among Hong Kong Chinese **Years of study:** 1994 to 1996 **Response rate:** 78% **Missing data:** Not reported	**Country trial conducted in:** Hong Kong **Ethnicity:** Hong Kong Chinese **Source of participants:** Population **Number:** 2,893 **Reported eligibility criteria:** Inclusion Aged 25 to 74y Exclusion Serious illness Hospitalised individuals	**Gender (% male):** 48.7% **Age (y), mean (SD):** 45.8 (12.9) **Baseline BMI (kg/m^2) and WC (cm), mean (SD):** BMI - 24.1 (3.6) WC - 79.1 (10.2) **Co-morbidity:** Hypertension - 18.1% Dyslipidaemia - 26.5% **Physical disease/health status:** Not reported	**Exposure(s)/Index Test:** BMI, WC **Objective exposure measurement/how measured:** Reported as using standard methods metting international quality control programmes. Specific methods not reported **Outcome(s)/Reference Test:** Diabetes **Objective outcome measurement/how measured:** FPG ≥7.0mmol/L, or 2h PG ≥11.1mmol/L, or use of hypoglycaemic medication **Other relevant outcomes:** None **Adjustments:** Age and sex	**Study authors' conclusions:** WHO Asian specific BMI cutoff values for defining obesity appear to be reasonable, while WC cutoff values are high. **Additional Notes:** Diabetes definition aligns with current ADA and WHO/IDF criteria. **Comments on statistical analysis, validity and applicability:**
Results					
Thomas, 2004 **Refid 328** **Hong Kong**	**OR by BMI (kg/m^2) quartile, 95% CI (if reported)**	**Prevalence (95% CI if reported) by BMI**	**OR by WC (cm) quartile, 95% CI (if reported)**	**Prevalence (95% CI if reported) by WC**	**Other:**
	Diabetes (newly diagnosed) 14.78 to 20.56: 1.0 (reference) 20.57 to 22.10: 1.3 (0.9 to 1.8) 22.11 to 23.52: 1.8 (1.2 to 2.5) 23.53 to 25.00: 2.0 (1.3 to 3.0)		**Diabetes (newly diagnosed)** 49.8 to 68.0: 1.0 (reference) 68.3 to 73.1: 1.1 (0.8 to 1.6) 73.3 to 78.3: 2.2 (1.5 to 3.3) 78.5 to 89.8: 3.6 (2.2 to 5.7)		

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Almajwal et al, 2009 **Study ID:** Refid 180 **Data source:** Eastern Province of Saudi Arabia survey of people aged 30 or over **Full Citation:** Almajwal AM, Al-Baghil NA, Batterham MJ et al. Performance of body mass index in predicting diabetes and hypertension: A study from the Eastern Province of Saudi Arabia. Ann Saudi Med. 2009; 29(6):437-45. **Sources of funding:** Not reported **Competing interests:** Not reported	**Study Design:** Cross sectional **Question/objective:** To assess the accuracy and usefulness of standard BMI cutoff values for predicting diabetes and hypertension in a Saudi population. **Years of study:** 2004 to 2005 **Response rate:** 30.4% **Missing data:** 4.4% of the sample did not undergo confirmatory diabetes testing	**Country trial conducted in:** Saudi Arabia **Ethnicity:** Middle Eastern **Source of participants:** Community **Number:** 195,851 **Reported eligibility criteria:** Inclusion Eastern Providence resident Age ≥30y Exclusion Pregnant women Non-Saudi residents	**Gender (% male):** 51.0% **Age (y), mean (SD):** Not reported **Baseline BMI (kg/m^2), mean (SD):** 29.69 (6.00) **Co-morbidity:** Hypertension - 15.6% **Physical disease/health status:** BMI 25 - 29.9 kg/m^2 - 35.1% BMI ≥ 30 kg/m^2 - 43.8% Diabetes - 17.2%	**Exposure(s)/Index Test:** BMI **Objective exposure measurement/how measured:** Weight was measured while in light clothing without shoes to the nearest 0.5kg using standard beam weight scales Height was measured while barefoot, feet together to the nearest centimetre **Outcome(s)/Reference Test:** Diabetes (prevalent) **Objective outcome measurement/how measured:** Diabetes defined as Capillary Fasting Blood Glucose ≥126mg/dL (≥7.0mmol/dL), or Capillary Random Blood Glucose Glucose ≥200mg/dL (≥11.0mmol/dL). Diabetes diagnosed in those with a positive history of diabetes, or with a positive screen for hyperglycaemia without a history of diabetes, with a confirmatory FPG ≥126mg/dL (≥7.0mmol/dL), CFGB ≥200mg/dL (≥11.0mmol/dL) or CRBG ≥270mg/dL (≥15.0mmol/dL) **Other relevant outcomes:** None **Adjustments:** Stratified by sex	**Study authors' conclusions:** Using BMI alone for identifying individuals at risk for diabetes in Saudi Arabia appears to have significant limitations. Misclassification rates were unacceptably high regardless of method of BMI cutoff optimisation or cutoff value used. **Additional Notes:** Diabetes classified according to capillary blood testing (CFPG, CRBG) and not venous blood testing (FPG) as recommended by current ADA and WHO/IMF guidance. The method of confirming participant history of diabetes (e.g. self-report, medical records) was not reported. This may result in misclassification of true diabetes status. **Comments on statistical analysis, validity and applicability:** Optimum cutoff values were identified using Distance in ROC ($=\surd(1-S_n)^2 + (1-S_p)^2$), as well as other criteria (i.e. maximising sum of sensitivity and specificity, smallest misclassification rate and significant associations between BMI and diabetes based on logistic regression).

Results					
Almajawal, 2009 **Refid 180** **Saudi Arabia**	**ROC AUC (95% CI if reported) for BMI**	**Optimised BMI cutoffs (kg/m^2); S_n and S_p (if reported)**	**ROC AUC (95% CI if reported) for WC**	**Optimised WC cutoffs (cm); S_n and S_p (if reported)**	**Other:** **PPV, NPV and Misclassification rate for optimised BMI cutoffs**
	Diabetes (prevalent) <u>Male</u> 0.566 (0.561 to 0.571) <u>Female</u> 0.618 (0.614 to 0.622)	**Diabetes (prevalent)** <u>Male</u> BMI - 28.50 S_n - 55% S_p - 54% <u>Female</u> BMI - 31.50 S_n - 58% S_p - 61%	N/A	N/A	<u>Male</u> BMI - 28.50 PPV - 19% NPV - 87% Misclassification rate - 91% <u>Female</u> BMI - 31.50 PPV - 25% NPV - 86% Misclassification rate - 81%

Bazian

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Diaz et al, 2007 **Study ID:** Refid 245 **Data source:** US National Health and Nutrition Examination Survey, Health Survey for England **Full Citation:** Diaz VA, Mainous AG, Baker R et al. How does ethnicity affect the association between obesity and diabetes? Diabetic Medicine. 2007;24:1199-204. **Sources of funding:** Robert Wood Johnson Foundation, National Institutes of Health, Health Resources and Services Administration **Competing interests:** None	**Study Design:** Cross sectional **Question/objective:** To assess the utility of BMI, WC and WHR in determining diabetes risk across ethnic groups **Years of study:** 2003 to 2004 **Response rate:** Not reported **Missing data:** Not reported	**Country trial conducted in:** USA, UK **Applicable Ethnicities:** South Asian Indian Pakistani Bangladeshi English Black Chinese US Black English White US White **Source of participants:** Community **Number:** 11,624 (total) 10,835 (scoped ethnicities) South Asian - 983 Indian - 535 Pakistani - 296 Bangladeshi - 152 English Black - 486 US Black - 793 Chinese - 199 English White - 6,260 US White - 2,114 **Reported eligibility criteria:** Inclusion Age ≥ 20y	**Gender (% male):** South Asian Indian - 49.4% Pakistani - 46.0% Bangladeshi - 50.7% English Black - 43.3% US Black - 50.1% Chinese - 48.7% English White - 46.5% US White - 50.1% **Age (y), mean (SD):** South Asian Indian - 44.8 (NR) Pakistani - 40.3 (NR) Bangladeshi - 38.4 (NR) English Black - 44.5 (NR) US Black - 46.2 (NR) Chinese - 40.2 (NR) English White - 50.9(NR) US White - 52.5 (NR) **Mean baseline BMI (kg/m^2):** South Asian Indian - 26.0 Pakistani - 27.6 Bangladeshi - 26.4 English Black - 28.5 US Black - 29.7 Chinese - 24.0 English White - 27.2 US White - 27.8 **Co-morbidity:** Not reported **Physical disease/health status:** Not reported	**Exposure(s)/Index Test:** BMI, WC **Objective exposure measurement/how measured:** Height measured to the nearest millimetre with the head aligned in the Frankfort horizontal plane, WC measured to the nearest millimetre after expiration **Other exposures:** WHR **Outcome(s)/Reference Test:** Diabetes (prevalent) Diagnosed diabetes Undiagnosed diabetes **Objective outcome measurement/ how measured:** Diagnosed diabetes based on self-report of a healthcare provider diagnosis Undiagnosed diabetes based on HbA_{1c} >6.1% **Other relevant outcomes:** Diabetes prevalence in participants with normal BMI (18.5-24.9kg/m^2) **Adjustments:** All analyses stratified by sex and age; results presented for participants aged ≥40y	**Study authors' conclusions:** WC demonstrates higher discriminant ability than BMI. Optimum cut points for predicting prevalent diabetes vary by ethnicity and gender **Additional Notes:** WHR demonstrated a higher discriminant ability than BMI, and resulted in a smaller range of cutoff values across ethnicities HbA_{1c} value for the defining diabetes lower than current ADA guidelines (6.1% vs. 6.5%); May lead to classification bias relative to current clinical practice. **Comments on statistical analysis, validity and applicability:** Presented results for participants aged ≥40 years only Unclear how sensitivity and specificity were used to derive optimum BMI/WC cutoff values (maximum sum of sensitivity and specificity? Shortest distance on ROC curve? Sensitivity=specificity?) Associated sensitivity and specificity not provided for BMI and WC cutoffs

Results					
Diaz, 2007 **Refid 245** **USA, UK**	**ROC AUC (95% CI if reported) for BMI**	**Optimised BMI cutoffs (kg/m^2); S_n and S_p (if reported)**	**ROC AUC (95% CI if reported) for WC**	**Optimised WC cutoffs (cm); S_n and S_p (if reported)**	**Other:**
	Diabetes (prevalent) Male South Asian Indian - 0.61 Pakistani - 0.57 Bangladeshi - 0.67 English Black - 0.59 US Black - 0.60 Chinese - 0.72 English White - 0.67 US White - 0.66 Female South Asian Indian - 0.63 Pakistani - 0.73 Bangladeshi - 0.60 English Black - 0.59 US Black - 0.61 Chinese - 0.79 English White - 0.66 US White - 0.65	**Diabetes (prevalent)** Male South Asian Indian - 26.5 Pakistani - 24.8 Bangladeshi - 24.2 English Black - 28.7 US Black - 31.7 Chinese - 24.6 English White - 28.2 US White - 29.5 Female South Asian Indian - 25.0 Pakistani - 30.0 Bangladeshi - 27.0 English Black - 28.1 US Black - 27.7 Chinese - 24.1 English White - 26.7 US White - 27.7	**Diabetes (prevalent)** Male South Asian Indian - 0.65 Pakistani - 0.51 Bangladeshi - 0.73 English Black - 0.67 US Black - 0.65 Chinese - 0.84 English White - 0.68 US White - 0.69 Female South Asian Indian - 0.66 Pakistani - 0.83 Bangladeshi - 0.65 English Black - 0.68 US Black - 0.69 Chinese - 0.79 English White - 0.72 US White - 0.71	**Diabetes (prevalent)** Male South Asian Indian - 97.2 Pakistani - 92.5 Bangladeshi - 95.8 English Black -100.2 US Black - 108.9 Chinese - 95.1 English White - 103.4 US White - 105.8 Female South Asian Indian - 88.7 Pakistani - 101.3 Bangladeshi - 87.5 English Black - 88.0 US Black - 104.6 Chinese - 83.7 English White - 91.4 US White - 95.9	**Total diabetes prevalence (%) in participants with normal BMI** South Asian Indian - 8.7%* Pakistani - 8.0%* Bangladeshi - 10.8%* English Black - 7.5%* US Black - 6.6%* Chinese - 4.9% English White - 3.4% US White - 5.3%* *p<0.05 (unadjusted) compared to English Whites

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Ho et al, 2003 **Study ID:** Refid 313 **Data source:** The Hong Kong Cardiovascular Risk Factor Prevalence Study **Full Citation:** Ho S-Y, Lam T-H, Janus ED. Waist to stature ratio is more strongly associated with cardiovascular risk factors than other simple anthropometric indices. Ann Epidemiol. 2003; 13(10):683-91. **Sources of funding:** Hong Kong Health Services Research Committee, University of Hong Kong, Hong Kong Research Grants Council, Hong Kong Society for the Aged **Competing interests:** Not reported	**Study Design:** Cross sectional **Question/objective:** To determine the best anthropometric index in relation to cardiovascular risk factors (including diabetes) **Years of study:** 1994 to 1996 **Response rate:** 78% response to telephone interview; 38% (n=2,900) response to physical examination invitation **Missing data:** Not reported	**Country trial conducted in:** Hong Kong **Ethnicity:** Chinese **Source of participants:** Community **Number:** 7,730 (selected for phone interview) 2,900 (completed phone interview + exam) 2,895 (after excluding pregnant women) **Reported eligibility criteria:** Inclusion Aged 25y to 74y Exclusion Serious illness (i.e. cancer) Hospitalisation Pregnancy	**Gender (% male):** 48.8% male **Age (y), mean (SD):** Male - 46.2 (13.3) Female - 45.4 (12.6) **Baseline BMI (kg/m^2) and WC (cm), mean (SD):** <u>BMI</u> Male - 24.3 (3.4) Female - 23.9 (3.8) <u>WC</u> Male - 83.1 (9.6) Female - 75.3 (9.4) **Co-morbidity (male, female):** CHD - 2.1%, 2.7% Hypertension - 9.8%, 11.9% Angina - 2.8%, 4.5% Hypercholesterolaemia - 44.3%, 39.4% Dyslipidemia - 59.9%, 46.3% **Physical disease/health status:** Current smoker - 35.3% (m), 3.9% (f) Former smoker - 12.4% (m), 0.6% (f)	**Exposure(s)/Index Test:** BMI, WC **Objective exposure measurement/how measured:** Height and weight measured in without shoes and in light clothing. Height measured to nearest 0.5cm, weight measured to nearest 0.1kg. Waist circumference was measured half way between the xiphisternum and umbilicus to the nearest 0.5cm. WC measured twice, and the mean of the measurements was used during data analysis. **Outcome(s)/Reference Test:** Diabetes (prevalent) **Objective outcome measurement/how measured:** Self-report, Fasting glucose ≥7.8mmol/L or 2hr glucose ≥11.1mmol/L **Other relevant outcomes:** Coronary heart disease and Stroke, measured by self-report of doctor's diagnosis **Adjustments:** Stratified by sex	**Study authors' conclusions:** BMI is inferior to WSR in predicting cardiovascular risk factors and related health conditions; WSR had the best overall predictive power among both male and female HK Chinese. **Additional Notes:** Fasting glucose level for the defining diabetes higher than current ADA or WHO/IDF recommendations (7.8mmol/L vs. 7.0mmol/L); 2hr glucose level the same as current recommendations. May lead to classification bias relative to current clinical practice. WSR also assessed; the optimal WSR cutoff value was 0.48 for both men and women **Comments on statistical analysis, validity and applicability:** Cutoff values identified by maximising sum of sensitivity and specificity. May not be suitable for identifiying WC cutoffs.

Bazian

Results					
Ho, 2003 **Refid 313** **Hong Kong**	**ROC AUC (95% CI if reported) for BMI**	**Optimised BMI cutoffs (kg/m²); S_n and S_p (if reported)**	**ROC AUC (95% CI if reported) for WC**	**Optimised WC cutoffs (cm); S_n and S_p (if reported)**	**Other:**
	Diabetes (prevalent) Males 0.67 (0.62 to 0.71) Females 0.71 (0.67 to 0.75) **Stroke** Males 0.56 (0.42 to 0.69) Females 0.44 (0.18 to 0.71)	**Diabetes (prevalent)** Males BMI - 24.42 S_n - 71.3% S_p - 56.4% Females BMI - 23.33 S_n - 81.4% S_p - 52.0% **Stroke** Males BMI - 22.24 S_n - 100.0% S_p - 27.1% Females BMI - 26.47 S_n - 42.9% S_p - 77.6%	**Diabetes (prevalent)** Males 0.71 (0.67 to 0.76) Females 0.76 (0.72 to 0.80) **Stroke** Males 0.58 (0.45 to 0.71) Females 0.59 (0.37 to 0.82)	**Diabetes (prevalent)** Males WC - 83.90 S_n - 76.0% S_p - 58.2% Females WC - 78.15 S_n - 74.5% S_p - 68.8% **Stroke** Males WC - 79.90 S_n - 90.9% S_p - 38.0% Females WC - 82.9 S_n - 42.9% S_p - 78.9%	

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Huxley et al, 2008 **Study ID:** Refid 352 **Data source:** Obesity in Asia Collaboration **Full Citation:** Huxley R, James WPT, Barzi F et al. Ethnic comparisons of the cross-sectional relationships between measures of body size with diabetes and hypertension. Obesity Reviews. 2008; 9(Suppl. 1):53-61. **Sources of funding:** National Health and Medical Research Council of Australia, National Heart Foundation of Australia, Sanofi Aventis **Competing interests:** Not reported	**Study Design:** Review (cross sectional) **Question/objective:** To systematically compare the strength and nature of the association between anthropometric indices and cardiovascular risk (including diabetes) among ethnicities **Years of study:** Not reported **Response rate:** Not reported **Missing data:** Not reported	**Country trial conducted in:** Australia, China , Hong Kong, India, Iran, Japan, Philippines, Singapore, South Korea, Taiwan, Thailand **Ethnicity:** Mixed Asian Hong Kong Chinese Chinese (mainland and Taiwan) Japan, Korea, Philippines, Singapore, Thailand South Asian Indian Middle Eastern Iranian White **Source of participants:** Not reported **Number:** 263,728 (total) Asian - 201,952 Australian - 61,776 **Reported eligibility criteria:** Inclusion Data on age, sex, weight, height, WC, hip circumference, FPG, BP, and smoking status Exclusion History of diabetes or taking diabetes medication	**Gender (% male):** 47.1% (total) **Age (y), mean (SD):** Males - 37 to 55 (means range) Females - 38 to 55 (means range) **Baseline BMI (kg/m^2) and WC (cm), mean (SD):** **BMI** Males - 21.0 to 27.2 (means range) Females - 21.2 to 27.5 (means range) **WC** Males - 78.2 to 97.5 (means range) Females - 72.0 to 87.5 (means range) **Co-morbidity:** **Hypertension** Males - 9.4% to 58.7% (prev. range) Females - 9.4% to 45.4% (prev. range) **Physical disease/health status:** Not reported	**Exposure(s)/Index Test:** BMI, WC **Objective exposure measurement/how measured:** Not reported **Outcome(s)/Reference Test:** Diabetes (prevalent) **Objective outcome measurement/how measured:** Diabetes defined as FPG ≥7mmol/L **Other relevant outcomes:** None **Adjustments:** ROC analysis stratified by sex.	**Study authors' conclusions:** At any given level of BMI or WC, the absolute risk of diabetes is higher among Asians than Caucasians for both sexes. **Additional Notes:** WHR also assessed; WHR cutoffs were common to both Asians and Caucasians. Diabetes definition aligns with ADA and WHO/IDF criteria. **Comments on statistical analysis, validity and applicability:** Cutoff values identified by maximising the sum of sensitivity and specificity on the ROC curve. May not be suitable for defining WC cutoff. ROC AUCs and cutoff values pooled for Asian ethnicities.
Results					
Huxley, 2008 **Refid 352** **Various**	**Prevalence (95% CI if reported) by BMI**	**Optimised BMI cutoffs (kg/m^2); S_n and S_p (if reported)**	**Prevalence (95% CI if reported) by WC**	**Optimised WC cutoffs (cm); S_n and S_p (if reported)**	**Other:**
	Diabetes (prevalent) BMI 24kg/m^2 Asian males - 5% Caucasian males - 2% Asian females - 5% Caucasian females - 1%	**Diabetes (prevalent)** Asian Males - 24 Caucasian Males - 28 Asian Females - 25 Caucasian Females - 28	**Diabetes (prevalent)** WC 90cm Asian males - 6% Caucasian males - 2% WC 80cm Asian females - 5% Caucasian females - 1%	**Diabetes (prevalent)** Asian Males - 85 Caucasian Male - 99 Asian Females - 80 Caucasian Female - 85	

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Jafar et al, 2006 **Study ID:** Refid 316 **Data source:** National Health Survey of Pakistan **Full Citation:** Jafar TH, Chaturvedi N, Pappas G. Prevalence of overweight and obesity and their association with hypertension and diabetes mellitus in an Indo-Asian population. CMAJ. 2006;175(9):1071-7. **Sources of funding:** US National Institutes of Health **Competing interests:** None	**Study Design:** Cross sectional **Question/objective:** To define Indo-Asian specific cutoff values for BMI in order to identify those at risk for diabetes and hypertension **Years of study:** 1990 to 1994 **Response rate:** 92.6% **Missing data:** Not reported	**Country trial conducted in:** Pakistan **Ethnicity:** South Asian Pakistani **Source of participants:** Community **Number:** 8,972 **Reported eligibility criteria:** Inclusion Age ≥15y Exclusion Pregnant women	**Gender (% male):** 49.2% **Age (y), mean (SD):** 36.8 (17.3) **Mean baseline BMI (kg/m^2):** Not reported **Co-morbidity:** Hypertension - 19.6% Proteinuria - 4.6% (of 7,748 participants with data) **Physical disease/health status:** Current smoker - 15.7% Current chew tobacco user - 11.2% BMI ≥ 23 kg/m^2 - 25.0% BMI ≥ 25 kg/m^2 - 15.7% BMI ≥ 27 kg/m^2 - 10.3% BMI ≥ 30 kg/m^2 - 5.7%	**Exposure(s)/Index Test:** BMI **Objective exposure measurement/ how measured:** Height and weight measured in light clothing without shoes **Outcome(s)/Reference Test:** Diabetes (prevalent) **Objective outcome measurement/how measured:** Non-fasting blood glucose concentration ≥140mg/dL (7.8mmol/L) or a history of diabetes **Other relevant outcomes:** Prevalence of diabetes based on current WHO Asian specific BMI cutoff values for overweight (23kg/m^2) Sensitivity and specificity for recommended BMI cutoff values **Adjustments:** Survey clusters, provinces, age, sex, urban residence, literacy, economic status, diet, cigarette use.	**Study authors' conclusions:** The findings support the use of Asian-specific thresholds in Pakistan for the definition of overweight. **Additional Notes:** Method for establishing history of diabetes not reported Diabetes defined based on outdated criteria; may underrepresent diabetes prevalence compared to current definitions (fasting blood glucose ≥126mg/dL or 7.0mmol/L) **Comments on statistical analysis, validity and applicability:** Unclear how sensitivity and specificity were maximised to derive optimum BMI/WC cutoff values (maximum sum of sensitivity and specificity? Shortest distance on ROC curve? Sensitivity=specificity?)

Bazian

Results					
Jafar, 2006 **Refid 316** **Pakistan**	**ROC AUC (95% CI if reported) for BMI**	**Optimised BMI cutoffs (kg/m^2); S_n and S_p (if reported)**	**ROC AUC (95% CI if reported) for WC**	**Optimised WC cutoffs (cm); S_n and S_p (if reported)**	**Other:**
	Diabetes (prevalent) Male 0.64 (0.63 to 0.66) Female 0.66 (0.65 to 0.68)	**Diabetes (prevalent)** Male BMI - 22.1 S_n - 56% S_p - 72% Female BMI - 22.9 S_n - 59% S_p - 72%	N/A	N/A	**S_n and S_p for current recommended BMI (kg/m^2) cutoff values** Male BMI - 23 S_n - 46% S_p - 78% BMI - 25 S_n - 29% S_p - 88% Female BMI - 23 S_n - 59% S_p - 73% BMI - 25 S_n - 42% S_p - 82%

Bazian

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Ko et al, 1999 **Study ID:** Refid 378 **Data source:** Not reported **Full Citation:** Ko GTC, Chan JCN, Cockram CS et al. Prediction of hypertension, diabetes, dyslipidaemia or albuminuria using simple anthropometric indexes in Hong Kong Chinese. Int J Obesity. 1999; 23:1136-42. **Sources of funding:** Not reported **Competing interests:** Not reported	**Study Design:** Cross sectional **Question/objective:** To determine the values of anthropometric indexes that are associated with cardiovascular risk factors (including diabetes) **Years of study:** Not reported **Response rate:** Not reported **Missing data:** Not reported	**Country trial conducted in:** Hong Kong **Ethnicity:** Chinese **Source of participants:** Occupational **Number:** 1,513 **Reported eligibility criteria:** Inclusion Employee from one of two worksites in a major public utility company and a regional hospital	**Gender (% male):** 60.1% **Age (y), mean (SD):** 37.5 (9.2) **Baseline BMI (kg/m^2) and WC (cm), mean (SD):** BMI - 23.3 (3.2) WC - 78.5 (8.5) **Co-morbidity:** Hypertension - 12.5% Dyslipidaemia - 48.1% Albuminuria - 8.1% **Physical disease/health status:** Not reported	**Exposure(s)/Index Test:** BMI, WC **Objective exposure measurement/how measured:** Height and weight were measured while in light clothing without shoes. Weight was measured to the nearest 0.1kg Waist circumference was measured to the nearest 0.5cm at the minimum circumference between the xiphoid process and umbilicus **Outcome(s)/Reference Test:** Diabetes (prevalent) **Objective outcome measurement/how measured:** Defined as FPG ≥7.8mmol/L and/or 2h PG ≥11.1mmol/L **Other relevant outcomes:** None **Adjustments:** Stratified by sex	**Study authors' conclusions:** Increasing BMI, WC and other anthropometric indices (e.g. WHR, WSR) are associated with increasing diabetes risk in Hong Kong Chinese. However, the current BMI and WC cutoff values used to define obesity in Caucasians may not be applicable to Chinese. **Additional Notes:** BMI cutoff and corresponding sensitivity and specificity reported as equivalent between males and females; unclear if this is an accurate reflection of the results or a reporting error Diabetes was defined using contemporary WHO criteria, which have since been updated. May lead to classification bias relative to current clinical practice. Study also assessed performance of WSR and WHR at predicting prevalent diabetes; both are associated with diabetes risk. **Comments on statistical analysis, validity and applicability:** Cutoff values reported as identified by maximising the sum of sensitivity and specificity; appears that convergence of sensitivity and specificity were used.

Bazian

Results					
Ko, 1999 **Refid 378** **Hong Kong**	**ROC AUC (95% CI if reported) for BMI**	**Optimised BMI cutoffs (kg/m^2); S_n and S_p (if reported)**	**ROC AUC (95% CI if reported) for WC**	**Optimised WC cutoffs (cm); S_n and S_p (if reported)**	**Other:**
	N/A	**Diabetes (prevalent)** Males BMI - 24.3 S_n - 66.5% S_p - 65.5% Females BMI - 24.3 S_n - 66.5% S_p - 65.5%	N/A	**Diabetes (prevalent)** Males WC - 84.0 S_n - 67.4% S_p - 67.2% Females WC - 78.4 S_n - 70.0% S_p - 70.0%	N/A

Bazian

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Mansour et al, 2007b **Study ID:** Refid 263 **Data source:** Not reported **Full Citation:** Mansour AA, Al-Jazairi MI. Cut-off values for anthropometric variables that confer increased risk of type 2 diabetes mellitus and hypertension in Iraq. Arch Med Res. 2007; 38:253-8. **Sources of funding:** Not reported **Competing interests:** Not reported	**Study Design:** Cross sectional **Question/objective:** To identify anthropometric index cutoff values associated with an increased risk of diabetes. **Years of study:** 2005 **Response rate:** Not reported **Missing data:** Not reported	**Country trial conducted in:** Iraq **Ethnicity:** Middle Eastern **Source of participants:** Community **Number:** 12,986 **Reported eligibility criteria:** Inclusion Aged ≥18y Exclusion Pregnant women	**Gender (% male):** 51.5% **Age (y), mean (SD):** 45.6 (15.7) **Baseline BMI (kg/m^2) and WC (cm), mean (SD):** BMI – 26.5 (6.6) WC – 91.7 (14.6) **Co-morbidity:** Hypertension – 17.3% **Physical disease/health status:** Not reported	**Exposure(s)/Index Test:** BMI, WC **Objective exposure measurement/how measured:** Waist circumference measured at the umbilical level using a plastic tape, while standing and breathing normally. Height (to nearest cm) and weight (to nearest 0.5kg) measured in light clothing and no shoes. **Outcome(s)/Reference Test:** Diabetes (prevalent) **Objective outcome measurement/how measured:** Diagnosed as FPG ≥126mg/dL on two occasions, or Symptoms of diabetes and a casual plasma glucose ≥200mg/dL (11.0 mmol/L), or history of diabetes **Other relevant outcomes:** None **Adjustments:** Stratified by sex	**Study authors' conclusions:** Identified cutoff values for BMI but not WC were consistent with current general WHO definitions of overweight. WHR has the strongest association with diabetes. The least reliable index was BMI. **Additional Notes:** FPG levels used to identify diabetes align with current ADA and WHO/IDF recommendations WHR and WSR were also assessed; both measures performed significantly better than BMI at predicting diabetes. **Comments on statistical analysis, validity and applicability:** Youden index (maximise sensitivity and specificity) used to identify BMI and WC cutoff values. May not be appropriate for WC cutoff values.

Results					
Mansour, 2007b **Refid 263** **Iraq**	**ROC AUC (95% CI if reported) for BMI**	**Optimised BMI cutoffs (kg/m^2); S_n and S_p (if reported)**	**ROC AUC (95% CI if reported) for WC**	**Optimised WC cutoffs (cm); S_n and S_p (if reported)**	**Other:**
	Diabetes (prevalent) Males 0.63 (0.62 to 0.65) Females 0.59 (0.57 to 0.60)	**Diabetes (prevalent)** Males BMI - 25.4 S_n - 66.0% S_p - 53.9% Females BMI - 26.1 S_n - 66.3% S_p - 47.4%	**Diabetes (prevalent)** Males 0.69 (0.67 to 0.71) Females 0.67 (0.65 to 0.69)	**Diabetes (prevalent)** Males WC - 90 S_n - 79.5% S_p - 49.4% Females WC - 91 S_n - 79.6% S_p - 47.2%	

Bazian

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Mirmiran et al, 2004 **Study ID:** Refid 318 **Data source:** Tehran Lipid and Glucose Study **Full Citation:** Mirmiran P, Esmaillzadeh A, Azizi F. Detection of cardiovascular risk factors by anthropometric measures in Tehranian adults: receiver operating characteristic (ROC) curve analysis. Eur J Clin Nutr. 2004; 58:1110-8. **Sources of funding:** Not reported **Competing interests:** Not reported	**Study Design:** Cross sectional **Question/objective:** To identify optimal cutoff values of anthropometric measures as indicators of cardiovascular risk factors (including diabetes) in Iranian adults **Years of study:** Not reported **Response rate:** Not reported **Missing data:** Not reported	**Country trial conducted in:** Iran **Ethnicity:** Middle Eastern **Source of participants:** Community **Number:** 10,522 **Reported eligibility criteria:** Inclusion Aged ≥18y and <74y Tehran resident	**Gender (% male):** 42.3% **Age (y), mean (SD):** Not reported **Baseline BMI (kg/m^2) and WC (cm), mean (SD):** Not reported (graph only, no data) **Co-morbidity:** Hypertension <u>Males</u> 18-34y - 6% 35-54y - 17% 55-74y - 46% <u>Females</u> 18-34y - 4% 35-54y - 24% 55-74y - 47% Dyslipidaemia <u>Males</u> 18-34y - 42% 35-54y - 63% 55-74y - 59% <u>Females</u> 18-34y - 23% 35-54y - 52% 55-74y - 71% **Physical disease/health status:** Not reported	**Exposure(s)/Index Test:** BMI, WC **Objective exposure measurement/how measured:** Weight assessed in minimal clothing without shoes with digital scales to the nearest 100g. Height assessed with a tape meter while standing, without shoes with shoulders in normal position. WC was measured at the narrowest level to the nearest 0.1cm. **Outcome(s)/Reference Test:** Diabetes (prevalent) **Objective outcome measurement/how measured:** Diabetes defined as FPG ≥ 126mg/dL (≥ 7.0mmol/L) **Other relevant outcomes:** None **Adjustments:** Stratified by age and sex	**Study authors' conclusions:** Identified BMI cutoff values were higher than those identified by WHO as optimal for Asian populations, and included those suggested for Caucasian populations. **Additional Notes:** Diabetes definition aligns with current ADA and WHO/IDF recommendations. Study examined WSR and WHR as well as BMI and WC; There were no significant differences between WHR or WRS and BMI or WC, except amongs 35-54 year old and 55-74 year old females. In this group WHR performed significantly better than BMI at identifying diabetics. **Comments on statistical analysis, validity and applicability:** Optimal cutoffs identified by the point of convergence of sensitivity and specificity. ROC analyses were stratified by age and sex, resulting in small numbers of cases in some groups (e.g. 18 to 34 year old males and females)

Results					
Mirmiran, 2004 **Refid 318** **Iran**	**ROC AUC (95% CI if reported) for BMI**	**Optimised BMI cutoffs (kg/m^2); S_n and S_p (if reported)**	**ROC AUC (95% CI if reported) for WC**	**Optimised WC cutoffs (cm); S_n and S_p (if reported)**	**Other:**
	Diabetes (prevalent) Males 18-34y - 0.72 (0.56 to 0.87) 35-54y - 0.61 (0.55 to 0.66) 55-74y - 0.55 (0.50 to 0.59) Females 18-34y - 0.60 (0.39 to 0.81) 35-54y - 0.60 (0.56 to 0.64) 55-74y - 0.49 (0.45 to 0.53)	**Diabetes (prevalent)** Males 18-34y - 25 35-54y - 27 55-74y - 26 Females 18-34y - 25.5 35-54y - 29 55-74y - 28	**Diabetes (prevalent)** Males 18-34y - 0.69 (0.52 to 0.87) 35-54y - 0.63 (0.58 to 0.69) 55-74y - 0.56 (0.52 to 0.61) Females 18-34y - 0.65 (0.49 to 0.81) 35-54y - 0.67 (0.63 to 0.71) 55-74y - 0.55 (0.51 to 0.59)	**Diabetes (prevalent)** Males 18-34y - 86 35-54y - 91 55-74y - 92 Females 18-34y - 82 35-54y - 93 55-74y - 95	

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Nyamdorj, 2010 **Study ID:** Refid 219 **Data source:** 34 cohorts in the DECODA and DECODE studies **Full Citation:** Nyamdorj R. Anthropometric measures of obesity-their association with type 2 diabetes and hypertension across ethnic groups PhD by publication. 2010. PhD by publication. **Sources of funding:** Not reported **Competing interests:** Not reported	**Study Design:** Literature review and meta-analysis of the 37 cohorts participating in the DECODA and DECODE studies **Question/objective:** To identify ethnic and sex-specific change point values of BMI and WC for the presence of diabetes **Years of study:** 2005 to 2010; included studies carried out between 1986 and 2006 **Response rate:** Not reported **Missing data:** Not reported	**Country trial conducted in:** Various (China, India, Mauritius, Cyprus, Finland, Italy, Spain, Sweden, Netherlands, UK) **Ethnicity:** South Asian Indian Chinese European **Source of participants:** Population, community and occupational **Number:** 56,038 **Reported eligibility criteria:** Inclusion Cohorts using BMI and WC measurements Data on FPG and 2h PG Individuals aged ≥30 years old Population-based studies with ransom sampling Exclusion Individuals with prior history of diabetes or hypertension	**Gender (% male):** 45.1% **Age (y), mean (SD):** Not reported **Baseline BMI (kg/m^2) and WC (cm), mean (SD):** Not reported **Co-morbidity:** Not reported **Physical disease/health status:** Not reported	**Exposure(s)/Index Test:** BMI, WC **Objective exposure measurement/how measured:** Various methods used across included studies: Waist most frequently measured at minimum circumference between lower rib margins and iliac crest; a few studies measured halfway between the xiphoid process and umbilicus or at the umbilicus. Method of measuring height and weight not reported **Outcome(s)/Reference Test:** Diabetes **Objective outcome measurement/how measured:** Diabetes defined as previous diagnosis, a FPG ≥7.0mmol/L or 2h PG ≥11.0mmol/L. **Other relevant outcomes:** None **Adjustments:** Age Stratified by sex	**Study authors' conclusions:** Mean change point for the detection of undiagnosed diabetes were higher in Europeans than Indians (7 to 8 units for BMI and 14-20cm for WC). **Additional Notes:** Academic dissertation; not published in a peer-reviewed journal. Method of establishing previous diabetes diagnosis not reported. Diabetes diagnostic criteria in line with current ADA and WHO/IDF guidelines. WC Bayesian cut point values for men and women across ethnicities are reported differently in the text compared to the table; table version reported in results section. **Comments on statistical analysis, validity and applicability:** Bayesian model-mean change points used to identify optimal BMI and WC cutoff values; ROC analysis also used to identify cutoff values however method of identifying the optimal cutoffs was not reported.

Bazian

Results					
Nyamdorj, 2010 **Refid 219** **Various**	**ROC AUC (95% CI if reported) for BMI**	**Optimised BMI cutoffs (kg/m^2); S_n and S_p (if reported)**	**ROC AUC (95% CI if reported) for WC**	**Optimised WC cutoffs (cm); S_n and S_p (if reported)**	**Other:**
		Undiagnosed diabetes Males Indian - 22.5 Chinese - 25.8 European - 27.0 Females Indian - 23.1 Chinese - 25.4 European - 28.2		**Undiagnosed diabetes** Males Indian - 85 Chinese - 87 European - 98 Females Indian - 82 Chinese - 82 European - 86	BMI Cutoff by Bayesian model-mean change points Males Indian - 21.5 (20.2 to 21.9) Chinese - 25.6 (24.0 to 26.9) European - 29.5 (29.0 to 29.9) Females Indian - 22.5 (22.0 to 23.0) Chinese - 25.2 (23.6 to 26.9) European - 29.4 (28.3 to 29.9) WC Cutoff by Bayesian model-mean change points Males Indian - 79 (77 to 82) Chinese - 84 (82 to 85) European - 99 (95 to 106) Females Indian - 75 (74 to 76) Chinese - 81 (79 to 82) European - 89 (86 to 91)

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Qiao et al, 2010 **Study ID:** Refid 388 **Data source:** 28 published studies, 4 prospective studies and 24 cross-sectional **Full Citation:** Qiao Q, Nyamdorj R. The optimal cutoff values and their performance of waist circumference and waist-to-hip ratio for diagnosing type II diabetes. Eur J Clin Nutr. 2010; 64:23-9. **Sources of funding:** Academy Finland **Competing interests:** None	**Study Design:** Review **Question/objective:** To review studies of optimal cutoff values for WC for assessing risk of type 2 diabetes **Years of study:** Not reported **Response rate:** Not reported **Missing data:** Not reported	**Country trial conducted in:** Various (Europe, USA, Hong Kong, Singapore, Tunisia) **Ethnicity:** Chinese Black Middle Eastern Mixed White **Source of participants:** Clinic, community, population **Number:** **Reported eligibility criteria:** Inclusion Published after 1975 English Report on optimal WC or WHR values Optimal values identified by max[S_n + S_p] or other valid methods	**Gender (% male):** Not reported **Age (y), mean (SD):** Not reported **Baseline BMI (kg/m^2) and WC (cm), mean (SD):** Not reported **Co-morbidity:** Not reported **Physical disease/health status:** Not reported	**Exposure(s)/Index Test:** BMI, WC **Objective exposure measurement/how measured:** Various measures used across studies **Outcome(s)/Reference Test:** Diabetes **Objective outcome measurement/how measured:** Various measures used across studies **Other relevant outcomes:** Previous history of diabetes, FPG or FPG and 2hr PG **Adjustments:** Not reported	**Study authors' conclusions:** Optimal cutoff values for BMI and WC vary across ethnicities, with no universal optimal value. **Additional Notes:** Cutoff values extracted only for studies that were not part of the current evidence review (either extracted or excluded based on sifting criteria). Values provided stratified by sex and ethnicity (country). **Comments on statistical analysis, validity and applicability:** Information of individual analysis methods not reported.

Results					
Qiao, 2010 **Refid 388** **Various**	**ROC AUC (95% CI if reported) for BMI**	**Optimised BMI cutoffs (kg/m^2); S_n and S_p (if reported)**	**ROC AUC (95% CI if reported) for WC**	**Optimised WC cutoffs (cm); S_n and S_p (if reported)**	**Other: Optimal WC cutoffs (cm) for the same ethnicities (obtained by combining studies side by side); (S_n and S_p) if reported**
	N/A	<u>Males</u> Chinese (HK) - 22.3 (89%, 56%) Black (USA) - 28 (61%, 68%) White (USA) - 28 (60%, 70%) White (Europe) - 28.0 (64%, 64%) <u>Females</u> Chinese (HK) - 18.4 (100%, 15%) Mix (Singapore) - 23.2 (96%, 57%) Black (USA) - 30 (63%, 60%) White (USA) - 27 (65%, 69%) White (Europe) - 27.8 (68%, 68%)	N/A	<u>Males</u> Chinese (HK) - 88.2 (78%, 67%) Black (USA) - 99 (61%, 71%) White (USA) - 101 (61%, 67%) White (Europe) - 103 (65%, 64%) <u>Females</u> Chinese (HK) - 85.3 (58%, 55%) Mix (Singapore) - 79.5 (89%, 74%) Black (USA) - 101 (62%, 68%) White (USA) - 95 (67%, 68%) White (Europe) - 94.0 (68%, 67%)	<u>Males</u> White (USA, UK) - 101-6 (61%, 67%) Chinese - 85 (50-97%, 58-70%) Chinese (USA, UK) - 95 Indian (India) - 85-87 (64-69%, 58-67%) Indian (USA, UK) - 97 Bangladeshi (USA, UK) - 96 Pakistani (USA, UK) - 93 Iranian (Iran) - 86-92 Iraqi (Iraq) - 90 (80%, 49%) African (USA) - 99 (61%, 71%) African - 88 (71%, 79%) Black (USA) - 109 -100 <u>Females</u> White (USA, UK) - 95 (67%, 68%) Chinese - 75-80 (58-78%, 66-77%) Chinese (USA, UK) - 84 Indian (India) - 80-83 (65-70%, 56-60%) Indian (USA, UK) - 89 Bangladeshi (USA, UK) - 88 Pakistani (USA, UK) - 101 Iranian (Iran) - 82-95 Iraqi (Iraq) - 91 (80%, 47%) African (USA) - 101 (62%, 68%) African - 85-89 (62%, 65%) Black (USA) - 105 - 88

Bazian

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Sarrafzadegan et al, 2010 **Study ID:** Refid 322 **Data source:** Isfahan Healthy Heart Program **Full Citation:** Sarrafzadegan N, Kelishadi R, Najafian A et al. Anthropometric indices in association with cardiometabolic risk factors: Findings for the Isfahan Healthy Heart Program. Atherosclerosis Journal. 2010; 5(4):152-62. **Sources of funding:** Iran Budget and Planning Organisation Deputy for Health of the Iranian Ministry of Health and Medical Education and Isfahan University of Medical Sciences **Competing interests:** None	**Study Design:** Cross sectional **Question/objective:** To determine the best anthropometric index for predicting cardiometabolic risk factors and identify the associated optimal cutoff values. **Years of study:** Not reported **Response rate:** Not reported **Missing data:** Not reported	**Country trial conducted in:** Iran **Ethnicity:** Middle Eastern **Source of participants:** Population **Number:** 12,514 **Reported eligibility criteria:** Inclusion Aged ≥19y Iranian nationality Mental competency Exclusion Pregnant women	**Gender (% male):** 48.9% **Age (y), mean (SD):** Male - 38.9 (15.2) Female - 38.8 (14.7) **Baseline BMI (kg/m^2) and WC (cm), mean (SD):** <u>BMI</u> Male - 24.5 (4.8) Female - 26.7 (5.9) <u>WC</u> Male - 88.4 (12.1) Female - 92.6 (14.1) **Co-morbidity:** Hypertension - 18.7% males, 18.9% females Metabolic Syndrome - 10.7% males, 35% females **Physical disease/health status:** Not reported	**Exposure(s)/Index Test:** BMI, WC **Objective exposure measurement/how measured:** Height was measured while standing barefoot to the nearest 0.5cm using a secured metal ruler, Weight was measured in light clothing using calibrated scales, Waist circumference was measured midway between the lower rib margin and iliac crest to the nearest 0.5cm **Outcome(s)/Reference Test:** Diabetes **Objective outcome measurement/how measured:** Method of identifying known cases of diabetes was not reported **Other relevant outcomes:** Abnormal FPG, defined as FPG >126mg/dL **Adjustments:** Stratified by sex	**Study authors' conclusions:** Cutoff values for anthropometric indices proposed in Western populations with taller populations may not be applicable to other ethnicities, requiring the use of different cutoff values in different populations. WSR was the best index for predicting risk factors. **Additional Notes:** WSR and WHR also assessed; WSR had significantly higher AUC values than BMI in males, but was not significantly higher in females (based on CIs). No significant difference in AUC values between WSR and WC, or WHR and BMI or WC. **Comments on statistical analysis, validity and applicability:** Optimal cutoff values identified by maximising the sum of sensitivity and specificity. May not be appropriate for WC cutoffs. .

Results					
Sarrafzadegan, 2010 Refif 322 Iran	ROC AUC (95% CI if reported) for BMI	Optimised BMI cutoffs (kg/m^2); S_n and S_p (if reported)	ROC AUC (95% CI if reported) for WC	Optimised WC cutoffs (cm); S_n and S_p (if reported)	Other:
	Known cases of diabetes Male 0.68 (0.65 to 0.71) Female 0.65 (0.62 to 0.67) **FPG >126mg/dL** Male 0.68 (0.65 to 0.71) Female 0.65 (0.62 to 0.68)	**Known cases of diabetes** Male BMI - 21.5 S_n - 90% S_p - 73% Female BMI - 23.0 S_n - 90% S_p - 72% **FPG >126mg/dL** Male BMI - 21.2 S_n - 90% S_p - 70% Female BMI - 23.1 S_n - 90% S_p - 72%	**Known cases of diabetes** Male 0.73 (0.70 to 0.76) Female 0.69 (0.66 to 0.71) **FPG >126mg/dL** Male 0.73 (0.70 to 0.76) Female 0.69 (0.66 to 0.71)	**Known cases of diabetes** Male WC - 80.7 S_n - 91% S_p - 70% Female WC - 84.7 S_n - 92% S_p - 71% **FPG >126mg/dL** Male WC - 80.7 S_n - 90% S_p - 70% Female WC - 84.7 S_n - 90% S_p - 70%	

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Shah et al, 2009 **Study ID:** Refid 395 **Data source:** Not reported **Full Citation:** Shah A, Bhandary S, Malik SL et al. Waist circumference and waist-hip ratio as predictors of type 2 diabetes mellitus in the Nepalese population of Kavre District. Nepal Med Coll J. 2009; 11(4):261-7. **Sources of funding:** Not reported **Competing interests:** Not reported	**Study Design:** Cross sectional **Question/objective:** To identify WC values that predict type 2 diabetes mellitus in the Kavre district of Nepal **Years of study:** Not reported **Response rate:** Not reported **Missing data:** Not reported	**Country trial conducted in:** Nepal **Ethnicity:** South Asian Nepalese **Source of participants:** Clinic **Number:** 100 **Reported eligibility criteria:** Inclusion Aged >30y Resident of the Kavre district Diabetics and their relatives, attending the Kathmandu University Teaching Hospital	**Gender (% male):** 53% male **Age (y), mean (SD):** 49.36 (14.06) **Baseline BMI (kg/m^2) and WC (cm), mean (SD):** **BMI** 23.41 (3.90) **WC** 82.50 (12.31) **Co-morbidity:** Not reported **Physical disease/health status:** Not reported	**Exposure(s)/Index Test:** BMI, WC **Objective exposure measurement/how measured:** Height (to the nearest cm) and weight (to the nearest kg) were assessed using a stadiometer and scale. Measurements taken with subjects in light clothing and without shoes. Waist circumference was measured after exhalation with a non-stretchable plastic tape and the minimum circumference between the costal margins and iliac crest. **Outcome(s)/Reference Test:** Diabetes **Objective outcome measurement/how measured:** Diabetes diagnosed according to a typical presentation and course with FPG ≥126mg/dL (7.0mmol/L), Random PG ≥200mg/dL (11.1mmol/L) or 2h PG ≥200mg/dL (11.1mmol/L) **Other relevant outcomes:** None **Adjustments:** Stratified by sex	**Study authors' conclusions:** WC and WHR are the best predictors of diabetes in both males and females in the Kavre district of Nepal **Additional Notes:** Diabetics (n=65) and non-diabetics (n=35) were recruited. Non diabetics were relatives of diabetic participants. This is unlikely to represent the prevalence of diabetes in a wider population, as a family history of DM is a risk factor for the condition. WHR also assessed; WHR had greater ROC AUC than BMI for both males and females, and than WC for females Diabetes diagnosis in line with ADA criteria **Comments on statistical analysis, validity and applicability:** Optimal cutoff values identified using the Youden index (max[S_n + S_p]. May not be appropriate for WC cutoff. Visual inspection of the ROC curves revealed that the BMI crossed the 0.50 references line for female subjects.

Results					
Shah, 2009 **Refid 395** **Nepal**	**ROC AUC (95% CI if reported) for BMI**	**Optimised BMI cutoffs (kg/m^2); S_n and S_p (if reported)**	**ROC AUC (95% CI if reported) for WC**	**Optimised WC cutoffs (cm); S_n and S_p (if reported)**	**Other:**
	Male 0.6851 Female 0.55	Male BMI - 23.63 (63.2%, 73.3%) Female BMI - 21.40 (74.1%, 50.0%)	Male 0.8702 Female 0.7019	Male WC - 87 (68.4%, 93.3%) Female WC - 85 (59.3%, 80.0%)	

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Zaher et al, 2009 **Study ID:** Refid 368 **Data source:** **Full Citation:** Zaher ZMM, Zambari R, Pheng CS et al. Optimal cut-off levels to define obesity: body mass index and waist circumference, and their relationship to cardiovascular disease, dyslipidaemia, hypertension and diabetes in Malaysia. Asia Pac J Clin Nutr. 2009; 18(2):209-16. **Sources of funding:** Sanofi-aventis **Competing interests:** Two of the study authors are employees of Sanofi-aventis	**Study Design:** Cross sectional **Question/objective:** To identify optimal cufoff levels for BMI and WC for cardiovascular risk factors **Years of study:** 2005 **Response rate:** Not reported **Missing data:** Not reported	**Country trial conducted in:** Malaysia **Ethnicity:** Asian Chinese South Asian Indian **Source of participants:** Clinic **Number:** 1,833 (total) Chinese - 546 Malaysian - 889 (out of scope) Indian - 326 Other - 55 **Reported eligibility criteria:** Inclusion Aged 21 to 80y Exclusion Pregnant women	**Gender (% male):** 47.6% **Age (y), mean (SD):** 44 (14) **Baseline BMI (kg/m^2) and WC (cm), mean (SD):** Not reported **Co-morbidity:** Hypertension - 27.1% Cardiovascular disease - 4.3% Lipid disorders - 17.7% **Physical disease/health status:** Current/former smoker - 31.0%	**Exposure(s)/Index Test:** BMI, WC **Objective exposure measurement/how measured:** Body weight, height and WC measured by the attending doctor. All doctors attended centralised training on how to make these measurements. Specific methods not reported **Outcome(s)/Reference Test:** Diabetes **Objective outcome measurement/how measured:** Not reported **Other relevant outcomes:** Not reported **Adjustments:** None	**Study authors' conclusions:** WC appears to be a better predictor of diabetes than BMI, with higher AUCs for both males and females. WC is better than BMI for the prediction of obesity related CVD risk factors. **Additional Notes:** ROC AUC indicates that the ability of BMI to identify prevalent diabetes is no better than chance among Chinese and Indian males, and Indian females. Method of defining diabetes unclear; data was collected on medical history (including diabetes) but it is not reported whether this data was obtained from medical records, self-report or other means. This could lead to misclassification of the participant's disease status. Inclusion in the study dependent on visit to a primary care clinic between May and September 2005. **Comments on statistical analysis, validity and applicability:** Method of identifying optimal cutoff values is unclear. BMI ROC AUC non significant for Chinese and Indian males, as well as Indian females. WC ROC AUC nonsignificant for Chinese males and Indian females

Results					
Zaher, 2009 **Refid 368** **Malaysia**	**ROC AUC (95% CI if reported) for BMI**	**Optimised BMI cutoffs (kg/m^2); (S_n and S_p (if reported)**	**ROC AUC (95% CI if reported) for WC**	**Optimised WC cutoffs (cm); S_n and S_p (if reported)**	**Other: S_n and S_p for guideline cutoff values for Caucasians (WHO) and Proposed criteria for the Asia Pacific region**
	Diabetes (prevalent) Males Combined - 0.59 (0.54, 0.64) Chinese - 0.58 (0.48 to 0.69) Indian - 0.55 (0.46 to 0.65) Females Combined - 0.61 (0.56, 0.66) Chinese - 0.67 (0.58 to 0.76) Indian - 0.50 (0.40 to 0.61)	**Diabetes (prevalent)** Males Combined - 25.5 (62.5%, 52.8%) Chinese - 25.5 (65.6%, 53.7%) Indian - 22.6 (90.5%, 28.1%) Females Combined - 24.9 (74.2%, 45.3%) Chinese - 24.3 (74.2% to 54.7%) Indian - 31.2 (83.3% to 26.7%)	**Diabetes (prevalent)** Males Combined - 0.64 (0.59, 0.69) Chinese - 0.60 (0.49 to 0.70) Indian - 0.64 (0.55 to 0.73) Females Combined - 0.68 (0.63, 0.72) Chinese - 0.71 (0.63 to 0.80) Indian - 0.56 (0.46 to 0.66)	**Diabetes (prevalent)** Males Combined - 92.0 (60.0%, 60.8%) Chinese - 97.0 (47.9%, 73.6%) Indian - 84.0 (92.9%, 34.4%) Females Combined - 88.0 (63.6%, 64.8%) Chinese - 77.0 (93.6% to 40.9%) Indian - 86.0 (75.0% to 44.2%)	**BMI** Males 23.0 - 81.6%, 45.6% 25.0 - 59.2%, 71.6% 30.0 - 10.7%, 97.2% Females 23.0 - 79.0%, 71.5% 25.0 - 54.1%, 86.2% 30.0 - 10.1%, 98.2% **WC** Males 102.0 - 3.7%, 99.0% 90.0 - 36.5%, 88.6% Females 80.0 - 50.6%, 91.4% 88.0 - 18.3%, 97.8%

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Stommel et al, 2010 **Study ID:** Refid 203 **Data source:** National Health Interview Survey **Full Citation:** Stommel M, Schoenborn CA. Variations in BMI and prevalence of health risks in diverse racial and ethnic populations. Obesity. 2010; 18(9):1821-6. **Sources of funding:** Not reported **Competing interests:** None	**Study Design:** Cross sectional **Question/objective:** To compare the prevalence of diabetes and other conditions among different ethnic groups and examine differences in the BMI health risk relationship for small BMI increments **Years of study:** 1997 to 2007 **Response rate:** 78.3% to 87.4% over years of study **Missing data:** BMI values missing for 4.4% of participants	**Country trial conducted in:** USA **Ethnicity:** Black Asian Chinese Japanese, Korean, Vietnamese White **Source of participants:** Community **Number:** 337,375 (total) Black - 47,468 Asian -5,553 White - 219,521 Non-scoped - 64,833 **Reported eligibility criteria:** Inclusion Aged ≥18y Non-institutionalised	**Gender (% male):** Not reported **Age (y), mean (SD):** Not reported **Baseline BMI (kg/m^2) and WC (cm), mean (SD):** Not reported **Co-morbidity:** Hypertension Black - 31.3% (30.6% to 31.9%) Asian -16.5% (15.3% to 17.9%) White - 25.1% (24.8% to 25.4%) CHD Black - 2.9% (2.7% to 3.1%) Asian -1.9% (1.5% to 2.3%) White - 4.4% (4.3% to 4.5%) Asthma Black - 10.7% (10.4% to 11.1%) Asian -6.1% (5.3% to 7.0%) White - 10.3% (10.2% to 10.5%) Functionally limiting arthritis Black - 10.1% (9.8% to 10.5%) Asian - 4.4% (3.7% to 5.1%) White - 11.1% (10.9% to 11.3%) **Physical disease/health status:** Not reported	**Exposure(s)/Index Test:** BMI **Objective exposure measurement/how measured:** Self-report of height and weight without shoes **Outcome(s)/Reference Test:** Diabetes **Objective outcome measurement/how measured:** Self report of diabetes diagnosis by a doctor **Other relevant outcomes:** None **Adjustments:** Prevalence adjusted for age, sex, education, poverty status, marital status, health insurance, urban vs. rural residency, foreign vs. domestic birth, smoking status, physical activity level and alcohol consumption	**Study authors' conclusions:** "Using the prevalence of five chronic conditions as the risk criterion, a categorization the BMI into normal, overweight, or obesity appears to be somewhat arbitrary, as there are no obvious BMI thresholds that divide the population into meaningful risk groups. However, for all population groups, except East Asians, a modest increased disease risk was noted for persons with a BMI <20 compared with persons with a BMI in the range of 20 - 21." **Additional Notes:** Exposure and outcome assessed using self-report **Comments on statistical analysis, validity and applicability:** Researchers applied a correction to self-reported BMI.

Results					
Stommel, 2010 **Refid 203** **USA**	**Prevalence (95% CI if reported) by BMI**	**Risk equivalent BMI values (kg/m^2) for European 25 kg/m^2 and 30 kg/m^2**	**Prevalence (95% CI if reported) by WC**	**Risk equivalent WC values (cm) for European 102 cm and 88 cm**	**Other:**
	Diabetes General US population <18.5: 2.7% 18.5 to <20: 2.0% 20 to <21: 1.9% 21 to <22: 2.4% 22 to <23: 2.7% 23 to <24: 3.2% 24 to <25: 3.8% 25 to <26: 4.4% 26 to <27: 4.6% 27 to <28: 5.8% 28 to <29: 7.1% 29 to <30: 7.9% 30 to <31: 7.6% 31 to <32: 9.8% 32 to <35: 11.3% 35 to <37: 14.9% 37 to <40: 16.9% ≥40: 21.5%	Graphical only	N/A	N/A	

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Stevens et al, 2008 **Study ID:** Refid 202 **Data source:** People's Republic of China Study, Atherosclerosis Risk in Communities Study **Full Citation:** Stevens J, Truesdale KP, Katz EG et al. Impact of body mass index on incident hypertension and diabetes in Chinese Asians, American Whites and American Blacks. Am J Epidemiol. 2008; 167:1365-74. **Sources of funding:** US National Institutes of Health **Competing interests:** None	**Study Design:** Cohort **Question/objective:** To evaluate and compare the association of BMI with diabetes and hypertension among Asians dwelling in China and Blacks and Whites dwelling in the United States **Years of study:** 1983 to 1994, and 1987 to 1998 **Mean follow-up:** 7.9 to 8.2 years **Response rate:** Not reported **Missing data:** Not reported Participants without data on BMI at baseline, or at follow-up visits or pertinent covariates were excluded	**Country trial conducted in:** USA, China **Ethnicity:** American Blacks Chinese Asians American Whites **Source of participants:** Community **Number:** American Blacks - 3,582 Chinese Asians - 5,980 American Whites - 10,776 **Reported eligibility criteria:** Inclusion Ages 45 to 64 years Classified as white or black (ARIC study) Exclusion Blacks from Washington County, Maryland or Minneapolis, Minnesota (ARIC study) Missing data on BMI at baseline, or at follow-up visits or pertinent covariates	**Gender (% male):** 46% **Age (y), mean (SD):** Males Chinese Asian - 51.1 (4.0) American Blacks - 53.6 (5.9) American Whites - 54.7 (5.7) Females Chinese Asian - 50.9 (4.4) American Blacks - 53.2 (5.7) American Whites - 53.9 (5.7) **Baseline BMI (kg/m^2) and WC (cm), mean (SD):** BMI Males Chinese Asian - 22.0 (3.3) American Blacks - 27.8 (4.9) American Whites - 27.4 (4.0) Females Chinese Asian - 22.4 (3.8) American Blacks - 30.8 (6.6) American Whites - 26.6 (5.4) **Co-morbidity:** Not reported **Physical disease/health status:** Current Smokers Male - 29.2% to 74.0% Female - 22.5% to 23.8% Current Drinkers Male - 49.9% to 69.9% Female - 3.5% to 61.1%	**Exposure(s)/Index Test:** BMI **Objective exposure measurement/how measured:** Height and weight were measured in light clothing or scrub suits without shoes, using a beam balance scale. **Outcome(s)/Reference Test:** Diabetes (incident) **Objective outcome measurement/how measured:** Diabetes defined as FPG ≥126mg/dL, Self-report of taking diabetes medication, Self-report of physician diagnosed diabetes **Other relevant outcomes:** None **Adjustments:** Sex, baseline age, education, smoking status, alcohol consumption, field centre	**Study authors' conclusions:** The difference in incidence of diabetes associated with BMI is greater in Chinese Asians than American Whites. **Additional Notes:** Diabetes assessed in part via self-report; may result in outcome misclassification. **Comments on statistical analysis, validity and applicability:** No sex and BMI interactions were found; both genders were combined in all further analyses. Logistic regression analysis conducted for each group. Estimated incident diabetes risk differences were adjusted to a selected common group or to the mean (where possible) in order to compared incidence and risk difference across ethnicities. Therefore, estimated probabilities were based on a non-smoker and non-drinker aged 53.2 years (mean age) for a population that was 54% female (combined samples sex distribution).

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Results					
Stevens, 2008 **Refid 202** **USA, China**	**ROC AUC (95% CI if reported) for BMI**	**Risk Differences (%) by BMI (kg/m^2) category; 95% CI (if reported)**	**ROC AUC (95% CI if reported) for WC**	**OR by WC (cm); 95% CI (if reported)**	**Other:**
	N/A	Chinese Asians <18.5: -1.6 (-24.7 to 21.5) 18.5 to <23.0: 0.0 (referent) 23.0 to <25.0: 4.9 (-30.6 to 40.4) 25.0 to <27.5: 9.7 (-57.3 to 76.6) 27.5 to <30.0: 14.5 (-94.3 to 123.3) 30.0 to <32.5: 18.9 (-186.7 to 224.5) ≥32.5: Not reported American Blacks <18.5: Not reported 18.5 to <23.0: 0.0 (referent) 23.0 to <25.0: 5.1 (-17.3 to 27.6) 25.0 to <27.5: 7.6 (-17.9 to 33.0) 27.5 to <30.0: 12.1 (-23.1 to 47.3) 30.0 to <32.5: 15.2 (-29.9 to 60.4) ≥32.5: 23.7 (-26.9 to 74.2) American Whites <18.5: 1.9 (-34.8 to 38.5) 18.5 to <23.0: 0.0 (referent) 23.0 to <25.0: 1.7 (-6.0 to 9.4) 25.0 to <27.5: 4.6 (-10.1 to 19.3) 27.5 to <30.0: 8.8 (-17.5 to 35.2) 30.0 to <32.5: 14.1 (-27.0 to 55.2) ≥32.5: 21.4 (-29.2 to 72.0)	N/A	N/A	Incidence of diabetes with BMI given in graphical format.

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Nyamdorj, 2010b **Study ID:** Refid 403 **Data source:** Diabetes Epidemiology: Collaborative Analysis of Diagnostic Criteria in Asia (DECODA), and Diabetes Epidemiology: Collaborative Analysis of Diagnostic Criteria in Europe (DECODE) **Full Citation:** Nyamdorj R, Pitkaniemi J, Tuomilehto J et al. Ethnic comparison of the association of undiagnosed diabetes with obesity. Int J Obesity. 2010; 34:332-9. **Sources of funding:** Finnish Academy, DPPH **Competing interests:** None	**Study Design:** Meta-analysis of cross sectional data **Question/objective:** To determine the prevalence of undiagnosed diabetes in several ethnic groups given the same level of BMI and WC **Years of study:** Not reported **Response rate:** Not reported **Missing data:** Not reported	**Country trial conducted in:** Various (China, Japan, India, Mauritius, Cyprus, Finland, Italy, Spain, Sweden, Netherlands, UK) **Ethnicity:** South Asian Indian Chinese European **Source of participants:** Not reported **Number:** 54,467 from 30 studies **Reported eligibility criteria:** Inclusion Aged ≥30y Cohorts using BMI, WC, WHR and/or WSR measures for obesity Data on FPG and 2h PG Exclusion Previously diagnosed diabetes	**Gender (% male):** 45.0% **Age (y), mean (SD):** Indian: 43 to 47 (mean range) European: 47 to 62 (mean range) Chinese: 46 to 58 (mean range) **Baseline BMI (kg/m^2) and WC (cm), mean (SD):** **BMI** <u>Male</u> Indian: 22.0 to 23.3 (mean range) European: 25.5 to 27.9 (mean range) Chinese: 24.3 to 26.6 (mean range) <u>Female</u> Indian: 23.7 to 24.5 (mean range) European: 25.2 to 28.1 (mean range) Chinese: 24.3 to 26.3 (mean range) **WC** <u>Male</u> Indian: 81.2 to 87.7 (mean range) European: 91.4 to 98.4 (mean range) Chinese: 83.5 to 89.9 (mean range) <u>Female</u> Indian: 77.5 to 84.4 (mean range) European: 77.6 to 86.9 (mean range) Chinese: 76.6 to 83.4 (mean range) **Co-morbidity:** Not reported **Physical disease/health status:** Not reported	**Exposure(s)/Index Test:** BMI, WC **Objective exposure measurement/how measured:** Waist circumference measured halfway between lower rib margin and iliac crest in most studies, 1 study measured WC at the umbilicus and 1 study measured halfway between the umbilicus and xyphoid process. Height and weight assessment methods not reported **Outcome(s)/Reference Test:** Diabetes **Objective outcome measurement/how measured:** Diabetes defined as FPG ≥7.0mmol/L or 2h OGTT PG ≥11.1mmol/L **Other relevant outcomes:** None **Adjustments:** Stratified by sex, adjusted for age, study	**Study authors' conclusions:** At the same BMI or WC levels, undiagnosed diabetes was most prevalent in Indians, least prevalent in Europeans and intermediate in Chinese. **Additional Notes:** Diabetes diagnostic criteria in line with current ADA and WHO/IDF guidelines. **Comments on statistical analysis, validity and applicability:** BMI categories defined by 1 unit (kg/m^{-2}) intervals, WC categories defined by 3 (cm) unit intervals. Asians and Europeans had data for different BMI and WC ranges due to data availability (Asians: ≤18kg/m^2 to ~31kg/m^2 and ~67cm to ~100cm; Europeans ~21 kg/m^2 to ~34 kg/m^2 and ~67cm to ~112cm.
Results					
Nyamdorj, 2010b **Refid 403** **Various**	**Prevalence (95% CI if reported) by BMI**	**Risk equivalent BMI values (kg/m^2) for European 25 kg/m^2 and 30 kg/m^2**	**Prevalence (95% CI if reported) by WC**	**Risk equivalent WC values (cm) for European 102 cm and 88 cm**	**Other:**
	Graph only, not extractable data	Graph only, not extractable data	Graph only, not extractable data	Graph only, not extractable data	

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Taylor et al, 2010 **Study ID:** Refid 63 **Data source:** Framingham Heart Study (FHS), Jackson Heart Study (JHS) **Full Citation:** Taylor HA Jr, Coady SA, Levy D et al. Relationships of BMI to cardiovascular risk factors differ by ethnicity. Obesity. 2010; 18(8): 1638-45. **Sources of funding:** National Institutes of Health **Competing interests:** None	**Study Design:** Cross sectional **Question/objective:** To assess how obesity is associated with cardiovascular risk factors in African Americans and whites of European ancestry **Years of study:** 1998 to 2005 **Response rate:** Not reported **Missing data:** Participants with missing data excluded	**Country trial conducted in:** USA **Ethnicity:** Black White **Source of participants:** Community **Number:** 9,275 (total) Black - 4,030 (JHS study) White - 5,245 (FHS study) **Reported eligibility criteria:** Inclusion Aged 35 to 74y Enrolled in the FHS or JHS BMI of 18.5 to 50.0 kg/m^2 Exclusion CVD Participants with missing data (BMI or covariates)	**Gender (% male):** JHS: 36% FHS: 46% **Age (y), mean (SD):** JHS: 54 FHS: 51 **Baseline BMI (kg/m^2) and WC (cm), mean (SD):** Not reported **Co-morbidity:** Hypertension, cholesterol, and lipids reported by BMI group **Physical disease/health status:** Smoking and alcohol intake reported by BMI group	**Exposure(s)/Index Test:** BMI **Objective exposure measurement/how measured:** Height and weight measured in examination gowns without shoes **Outcome(s)/Reference Test:** Diabetes **Objective outcome measurement/how measured:** Diabetes defined by FPG ≥126mg/dL, or Casual PG ≥200mg/dL, or Use of insulin or oral hypoglycaemic medications at the time of examination **Other relevant outcomes:** None **Adjustments:** Age, sex, smoking status and education	**Study authors' conclusions:** Diabetes is more prevalent in African Americans compared to whites in all BMI categories. **Additional Notes:** DM defined according to insulin use; could introduce classification bias via the inclusion of Type 1 DM in the analysis. Such a misclassification could overestimate the prevalence **Comments on statistical analysis, validity and applicability:** Framingham Heart study comprised of mainly whites of European descent; lack of data on ethnicity within this cohort may confound comparison results. In the main publication, results presented for participants aged 34 to 54 years only. Prevalence data is available of participants aged 55-74 years old in the supplementary information.

Results					
Taylor, 2010 **Refid 63** **USA**	**Prevalence (95% CI if reported) by BMI**	**Risk equivalent BMI values (kg/m^2) for European 25 kg/m^2 and 30 kg/m^2**	**Prevalence (95% CI if reported) by WC**	**Optimised WC cutoffs (cm); S_n and S_p (if reported)**	**Other:**
	Diabetes (participants aged 34 to 54 years) Black (JHS) 18.5 to 24.99: 3.2% 25 to 29.99: 6.2% 30 to 34.99: 13.6% 35 to 50: 17.2% White (FHS) 18.5 to 24.99: 0.5% 25 to 29.99: 2.2% 30 to 34.99: 3.9% 35 to 50: 14.8% **Diabetes** (participants aged 55 to 74 years) Black (JHS) 18.5 to 24.99: 9.8% 25 to 29.99: 20.0% 30 to 34.99: 25.8% 35 to 50: 33.8% White (FHS) 18.5 to 24.99: 4.0% 25 to 29.99: 8.3% 30 to 34.99: 15.4% 35 to 50: 30.5%	N/A	N/A	N/A	**OR (95% CI) for diabetes** (participants aged 34 to 54 years) Black (JHS) 18.5 to 24.99: 1.0 (reference) 25 to 29.99: 1.93 (0.93 to 4.01) 30 to 34.99: 4.49 (2.22 to 9.08) 35 to 50: 6.51 (3.22 to 13.16) White (FHS) 18.5 to 24.99: 1.00 (reference) 25 to 29.99: 3.59 (1.55 to 8.34) 30 to 34.99: 6.32 (2.65 to 15.09) 35 to 50: 27.72 (12.36 to 62.19)

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Cameron et al, 2010 **Study ID:** Refid 442 **Data source:** Mauritius non-communicable disease survey, Australian Diabetes, Obesity and Lifestyle study (AusDiab) **Full Citation:** Cameron AJ, Sicree RA, Zimmet PZ et al. Cut-points for waist circumference in Europids and South Asians. Obesity. 2010; 18(10):2039-2046. **Sources of funding:** National Heart Foundation of Australia **Competing interests:** None	**Study Design:** Cohort **Question/objective:** To assess the appropriateness of high waist circumference cut-points for Europids compared to South Asian populations in terms of Type 2 Diabetes risk **Years of study:** 1987 to 1992 (Mauritius) 1999 to 2005 (AusDiab) **Mean follow-up:** Not reported **Response rate:** 80% (Mauritius) 55% (AusDiab) **Missing data:** 74% follow-up (Mauritius) 59% follow-up (AusDiab) Participants with missing data at baseline or follow-up were excluded	**Country trial conducted in:** Mauritius and Australia **Ethnicity:** South Asian Caucasian (Europid ancestry) **Source of participants:** Population **Number:** 7,729 (total) South Asian - 2,214 Caucasian - 5,515 **Reported eligibility criteria:** Inclusion Aged 25 or older Enrolled in AusDiab or Mauritius non-communicable disease survey Exclusion Baseline diabetes Pregnant women Participants with missing data (WC or diabetes status at baseline or follow-up)	**Gender (% male):** Mauritius: 45.9% AusDiab: 45.5% **Age (y), mean (SD):** Mauritius: 40.7 (12.0) AusDiab: 51.1 (12.6) **Baseline BMI (kg/m^2) and WC (cm), mean (SD):** BMI Mauritius: 23.3 (4.2) AusDiab: 26.8 (4.6) WC Mauritius: 77.2 (10.1) AusDiab: 90.1 (13.4) **Co-morbidity:** Not reported **Physical disease/health status:** Current Smokers Mauritius - 26.8% AusDiab - 11.4%	**Exposure(s)/Index Test:** WC **Objective exposure measurement/how measured:** Mauritius: narrowest point between the xiphisternum and umbilicus AusDiab: midway between lower border of ribs and ilicac crest **Outcome(s)/Reference Test:** Diabetes **Objective outcome measurement/how measured:** Diabetes defined by 2006 WHO criteria: FPG ≥126mg/dL (7.0mmol/L), 2-hour plasma glucose ≥200mg/dL (11.1mmol/L) **Other relevant outcomes:** None **Adjustments:** Stratified by population and gender, adjusted for age and age squared	**Study authors' conclusions:** South Asian participants exhibited high risk for diabetes at WC values considered normal; Recommended WC cut-points in South Asians should be lowered. **Additional Notes:** To account for difference in WC measurement methods, researchers added 1.5cm to the measurements of South Asian males and 2.7cm to the measurements of South Asian females, based on the results of a previous study of variation in mean WC values using different measures in a multi-ethnic population. **Comments on statistical analysis, validity and applicability:** Estimated diabetes incidence compared for two different time periods between populations.
Results					
Cameron, 2010 **Refid 442** **Mauritius and Australia**	**Incidence (95% CI if reported) by BMI**	**Risk equivalent BMI values (kg/m^2) for European 25 kg/m^2 and 30 kg/m^2**	**Incidence (95% CI if reported) by WC**	**Risk equivalent WC values (cm) for European 102 cm and 88 cm**	**Other:**
	N/A	N/A	N/A	Graph only	

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Pan et al, 2004 **Study ID:** Refid 440 **Data source:** Nutrition and Healthy Survey in Taiwan (NAHSIT), United States National Health and Nutrition Examination Survey (NHANES III) **Full Citation:** Pan W-H, Flegal KM, Chang H-Y et al. Body mass index and obesity-related metabolic disorders in Taiwanese and US whites and blacks: implications for definitions of overweight and obesity for Asians. Am J Clin Nutr. 2004; 79(1): 31-9. **Sources of funding:** Republic of China Department of Health **Competing interests:** Not reported	**Study Design:** Cross sectional **Question/objective:** To compare the relationship between BMI and Type 2 Diabetes among ethnicities **Years of study:** 1993 to 1996 (Taiwan) 1988 to 1994 (USA) **Response rate:** 74% (Taiwan) Not reported (USA) **Missing data:** 52.2% complete data (Taiwan) Not reported (USA)	**Country trial conducted in:** Taiwan and USA **Ethnicity:** Chinese Black White **Source of participants:** Population **Number:** 14,295 (total) Chinese - 3,047 Black - 4,542 White - 6,706 **Reported eligibility criteria:** Inclusion Aged 20 years or older Enrolled in NAHSIT or NHANES III Exclusion BMI ≤16 kg/m^2 or ≥40 kg/m^2	**Gender (% male):** Chinese: 51.0% Black: 45.1% White: 48.6% **Age (y), mean (SD):** Not reported **Baseline BMI (kg/m^2) and WC (cm), median (SD):** <u>BMI males</u> Chinese: 22.8 Black: 25.8 White: 26.0 <u>BMI females</u> Chinese: 22.4 Black: 27.6 White: 24.6 **Co-morbidity:** <u>Hypertension</u> Chinese: 23.3% Black: 30.7% White: 25.0% <u>Hypercholesterolemia</u> Chinese: 11.6% Black: 18.1% White: 22.4% <u>Hypertriglyceridemia</u> Chinese: 10.9% Black: 7.0% White: 16.8% **Physical disease/health status:** Not reported	**Exposure(s)/Index Test:** BMI **Objective exposure measurement/how measured:** Taiwan: weight measured to the nearest 0.1kg, height to the nearest 1mm in light clothing or an examination gown. USA: not reported **Outcome(s)/Reference Test:** Diabetes **Objective outcome measurement/how measured:** Taiwan: Fasting blood glucose concentration ≥6.1 mmol/L USA: FPG ≥7.0mmol/L **Other relevant outcomes:** None **Adjustments:** Stratified by BMI and ethnicity, age- and sex- standardised	**Study authors' conclusions:** A lower BMI cutoff value among Asians may be appropriate, but it is not clear where to set the value. **Additional Notes:** Taiwanese sample had a lower proportion of participants over the age of 65 years than the USA sample. **Comments on statistical analysis, validity and applicability:** Estimated diabetes incidence compared for two different time periods between populations.
Results					
Pan, 2004 **Refid 440** **Taiwan and USA**	**Prevalence (95% CI if reported) by BMI**	**Risk equivalent BMI values (kg/m^2) for European 25 kg/m^2 and 30 kg/m^2**	**Prevalence (95% CI if reported) by WC**	**Risk equivalent WC values (cm) for European 102 cm and 88 cm**	**Other:**
	N/A	Graph only	N/A	N/A	

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Stevens et al, 2002 **Study ID:** Refid 441 **Data source:** Cancer Prevention Study I (CPS-I), Atherosclerosis Risk in Communities Study (ARIC) **Full Citation:** Stevens J, Juhaeri JC, and Jones DW. The effect of decision rules on the choice of body mass index cutoff for obesity: examples from African American and white women. Am J Clin Nutr. 2002; 75(6):986-92. **Sources of funding:** American Heart Association **Competing interests:** Not reported	**Study Design:** Cohort **Question/objective:** To estimate the BMI value in black women that is associated with a risk equivalent to a BMI of 30 kg/m^2 among white women. **Years of study:** 1960 to 1972 (CPS-I) 1987 to 1989 (ARIC) **Mean follow-up:** Not reported **Response rate:** Not reported **Missing data:** 9.6% (CPS-I) 7.2% (ARIC) Participants with missing data at were excluded from analysis	**Country trial conducted in:** USA **Ethnicity:** Black White **Source of participants:** Population and community **Number:** <u>CPS-I</u> Black - 3,160 White - 193,135 <u>ARIC</u> Black - 2,304 White - 5,715 **Reported eligibility criteria:** Inclusion Aged 45 to 64 at baseline Female Exclusion Previous heart disease, stroke, or cancer at baseline Death within first year of follow-up period Pregnant at baseline Participants with missing data (WC or diabetes status at baseline or follow-up) Involuntary weight loss ≥4.5 kg in the previous two years Current and former smokers	**Gender (% male):** 0% **Age (y), mean (SD):** CPS-I: Black: 53.0 (5.4) White: 53.6 (5.5) ARIC: Black: 53.2 (5.7) White: 54.0 (5.7) **Baseline BMI (kg/m^2) and WC (cm), mean (SD):** <u>BMI</u> CPS-I: Black: 28.0 (5.5) White: 25.0 (4.2) ARIC: Black: 30.8 (6.1) White: 26.6 (5.1) **Co-morbidity:** Not reported **Physical disease/health status:** <u>Current or former smokers</u> Black: NR (CPS-I), 41.2% (ARIC) White: NR (CPS-I), 48.6% (ARIC) <u>Current drinkers</u> Black: 13.3% (CPS-I), 20.6% (ARIC) White: 18.8% (CPS-I), 60.1% (ARIC) <u>Low or Moderate Physical Activity</u> Black: 82.8% (CPS-I), 95.4% (ARIC) White: 90.3% (CPS-I), 87.7% (ARIC)	**Exposure(s)/Index Test:** BMI **Objective exposure measurement/how measured:** CPS-I: self-reported height and weight (without shoes and in light clothing) ARIC: height measured to nearest cm, using wall mounted metal ruler; weight assessed in scrub suit without shoes, using beam balance **Outcome(s)/Reference Test:** Diabetes **Objective outcome measurement/how measured:** FPG ≥126mg/dL (6.99mmol/L), non-fasting plasma glucose ≥200mg/dL (11.1mmol/L), self-reported physician diagnosis or self-reported diabetes medication use **Other relevant outcomes:** All cause mortality **Adjustments:** Diabetes analysis (ARIC): smoking status, study centre, age, education, physical activity and alcohol consumption Mortality analysis (CPS-I): age, education, physical activity, alcohol consumption	**Study authors' conclusions:** Absolute risk equivalent cut-off values vary depending on the outcome of interest. **Additional Notes:** Self-reported height and weight used to calculate BMI, may misclassify exposure value. Self-reported diabetes diagnosis or medication use included as diabetes diagnostic criteria, which may misclassify cases compared to current UK practice. **Comments on statistical analysis, validity and applicability:** Incidence rate, rate ratio and rate difference (using 21.0 kg/m^2 as the reference) were calculated and used to estimate the risk associated with a BMI of 30 kg/m^2 among white women. Analysis based on 20 to 50 year old data, may reduce applicability to current UK practice. Association between BMI and ACM among black women was not statistically significant at $p<0.05$.
Results					
Stevens, 2002 **Refid 441** **USA**	**Incidence rate among white women at 30 kg/m^2**	**Risk equivalent BMI values (kg/m^2) for 30 kg/m^2 - diabetes**	**Incidence (95% CI if reported) by WC**	**Risk equivalent WC values (cm) for European 102 cm and 88 cm**	**Risk equivalent BMI values (kg/m^2) for 30 kg/m^2 - ACM**
	Diabetes: graph only ACM: 8.04/1,000 person-years	Incidence rate: 28 kg/m^2	N/A	N/A	Incidence rate: 18 kg/m^2* * association not significant

Appendix 6 - Extraction Summary Table

Study	Ethnicity						Setting			Exposure		Outcome		Study Design			Question				Score
	Black	South Asian	Middle Eastern	Chinese	Mixed	White	UK	Other Western	Country of Origin	BMI	WC	Diabetes	Other	Cross Sectional	Cohort	Review/MA/Other	Q1	Q2	Q3	Q4	
MacKay, 2009	•					•		•		•	•	•			•		•				+/+
Sargeant, 2002	•								•	•	•	•			•		•		•		+/-
Hadaegh, 2006			•						•	•	•	•			•		•	•			+/+
Hadaegh, 2009			•						•	•	•	•			•		•	•			+/+
Janghorbani, 2009			•						•	•	•	•			•		•				+/-
Mansour, 2007			•						•	•	•	•			•		•				++/+
Taylor, 2009	•					•		•		•		•		•				•		•	++/+
Snehalatha, 2003		•							•	•	•	•		•				•	•		-/-
Thomas, 2004				•					•	•	•	•		•				•			+/+
Qiao, 2010	•	•		•	•	•	•	•	•	•	•	•				•			•		+/+
Diaz, 2007	•	•		•		•	•	•		•	•	•		•					•		+/+
Nyamdorj, 2010		•		•		•	•	•	•	•	•	•				•			•		+/+
Jafar, 2006		•							•	•		•		•					•		+/-
Mohan, 2007		•							•	•	•	•		•					•		+/-
Shah, 2009		•							•	•	•	•		•					•		-/-
Zaher, 2009		•		•					•	•	•	•		•					•		-/-
Mansour, 2007			•						•	•	•	•			•		•		•		++/+
Almajwal, 2009			•						•	•		•		•					•		-/-
Mansour, 2007b			•						•	•	•	•		•					•		+/+
Mirmiran, 2003			•						•	•	•	•		•					•		++/+
Sarrafzadegan, 2010			•						•	•	•	•		•					•		+/-
Ho, 2003				•					•	•	•	•	•	•					•		-/-

Appendix 6 - Extraction Summary Table

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Study	Ethnicity						Setting			Exposure		Outcome		Study Design			Question				Score
	Black	South Asian	Middle Eastern	Chinese	Mixed	White	UK	Other Western	Country of Origin	BMI	WC	Diabetes	Other	Cross Sectional	Cohort	Review/MA/Other	Q1	Q2	Q3	Q4	
Ko, 1999				•					•	•	•	•		•					•		+/-
Huxley, 2008					•	•		•	•	•	•	•				•			•		+/+
Chiu, 2011	•	•		•		•		•		•		•			•					•	+/+
Stevens, 2008	•			•		•		•	•	•		•			•					•	+/+
Stommel, 2010	•			•		•		•		•		•		•						•	+/+
Nyamdorj, 2010b		•		•		•	•	•	•	•	•	•				•					+/++
Cameron, 2010		•				•		•	•		•	•			•					•	+/-
Pan, 2004	•			•		•		•	•	•		•		•						•	+/+
Stevens, 2002	•					•			•	•		•	•		•					•	++/+

Study: Cameron AJ, Sicree RA, Zimmet PZ et al. Cut-points for waist circumference in Europids and South Asians. Obesity. 2010; 18(10):2039-2046. Refid 442.	Question no: 4			
Is the source population or source area well described?	Yes	No	**Unclear**	N/A
Is the eligible population or area representative of the source population or area?	Yes	No	**Unclear**	N/A
Do the selected participants or areas represent the eligible population or area?	Yes	No	**Unclear**	N/A
Were likely confounding factors identified and controlled?	Yes	**No**	Unclear	N/A
Is the setting applicable to the UK?	Yes	No	**Unclear**	N/A
Were the outcome measures and procedures reliable?	**Yes**	No	Unclear	N/A
Were the outcome measures complete?	**Yes**	No	Unclear	N/A
Was follow-up time sufficient?	**Yes**	No	Unclear	N/A
Were multiple explanatory variables considered in the analysis?	**Yes**	No	Unclear	N/A
Were the analytical methods appropriate?	Yes	**No**	Unclear	N/A
Was the precision of the association given or calculable? Is association meaningful?	**Yes**	No	Unclear	N/A
Are the study results internally valid?	++	**+**	-	
Are the study results applicable to the UK?	++	+	**-**	

Study: Chiu M, Austin PC, Manuel DG et al. Deriving ethnic-specific BMI cutoff points for assessing diabetes risk. Diabetes Care. 2011; 34:1741-8. Refid 342.	Question no: 4			
Is the source population or source area well described?	Yes	No	**Unclear**	N/A
Is the eligible population or area representative of the source population or area?	Yes	No	**Unclear**	N/A
Do the selected participants or areas represent the eligible population or area?	**Yes**	No	Unclear	N/A
Were likely confounding factors identified and controlled?	Yes	No	**Unclear**	N/A
Is the setting applicable to the UK?	**Yes**	No	Unclear	N/A
Were the outcome measures and procedures reliable?	Yes	No	**Unclear**	N/A
Were the outcome measures complete?	Yes	No	**Unclear**	N/A
Was follow-up time sufficient?	**Yes**	No	Unclear	N/A
Were multiple explanatory variables considered in the analysis?	**Yes**	No	Unclear	N/A
Were the analytical methods appropriate?	**Yes**	No	Unclear	N/A
Was the precision of the association given or calculable? Is association meaningful?	**Yes**	No	Unclear	N/A
Are the study results internally valid?	++	**+**	-	
Are the study results applicable to the UK?	++	**+**	-	

Study: Pan W-H, Flegal KM, Chang H=Y et al. Body mass intex and obesity-related metabolic disorders in Taiwanese and US whites and blacks: implications for definitions of overweight and obesity for Asians. Am J Clin Nutr. 2004; 79: 31-9. Refid 440.	Question no: 4			
Is the source population or source area well described?	Yes	No	**Unclear**	N/A
Is the eligible population or area representative of the source population or area?	Yes	No	**Unclear**	N/A
Do the selected participants or areas represent the eligible population or area?	Yes	No	**Unclear**	N/A
Were likely confounding factors identified and controlled?	Yes	**No**	Unclear	N/A
Is the setting applicable to the UK?	Yes	No	**Unclear**	N/A
Were the outcome measures and procedures reliable?	**Yes**	No	Unclear	N/A
Were the outcome measures complete?	**Yes**	No	Unclear	N/A
Was follow-up time sufficient?	Yes	No	Unclear	**N/A**
Were multiple explanatory variables considered in the analysis?	**Yes**	No	Unclear	N/A
Were the analytical methods appropriate?	**Yes**	No	Unclear	N/A
Was the precision of the association given or calculable? Is association meaningful?	Yes	**No**	Unclear	N/A
Are the study results internally valid?	++	**+**	-	
Are the study results applicable to the UK?	++	**+**	-	

Study: Stevens J, Juhaeri JC, and Jones DW. The effect of decision rules on the choice of body mass index cutoff for obesity: examples from African American and white women. Am J Clin Nutr. 2002; 75(6):986-92. Refid 441.	Question no: 4			
Is the source population or source area well described?	Yes	No	**Unclear**	N/A
Is the eligible population or area representative of the source population or area?	Yes	No	**Unclear**	N/A
Do the selected participants or areas represent the eligible population or area?	Yes	No	**Unclear**	N/A
Were likely confounding factors identified and controlled?	**Yes**	No	Unclear	N/A
Is the setting applicable to the UK?	**Yes**	No	Unclear	N/A
Were the outcome measures and procedures reliable?	**Yes**	No	Unclear	N/A
Were the outcome measures complete?	**Yes**	No	Unclear	N/A
Was follow-up time sufficient?	**Yes**	No	Unclear	N/A
Were multiple explanatory variables considered in the analysis?	**Yes**	No	Unclear	N/A
Were the analytical methods appropriate?	**Yes**	No	Unclear	N/A
Was the precision of the association given or calculable? Is association meaningful?	Yes	**No**	Unclear	N/A
Are the study results internally valid?	**++**	+	-	
Are the study results applicable to the UK?	++	**+**	-	

Study: Stevens J, Truesdale KP, Katz EG et al. Impact of body mass index on incident hypertension and diabetes in Chinese Asians, American Whites and American Blacks. Am J Epidemiol. 2008; 167:1365-74. Refid 202.	Question no: 4			
Is the source population or source area well described?	**Yes**	No	Unclear	N/A
Is the eligible population or area representative of the source population or area?	Yes	No	**Unclear**	N/A
Do the selected participants or areas represent the eligible population or area?	Yes	No	**Unclear**	N/A
Were likely confounding factors identified and controlled?	Yes	No	**Unclear**	N/A
Is the setting applicable to the UK?	**Yes**	No	Unclear	N/A
Were the outcome measures and procedures reliable?	Yes	No	**Unclear**	N/A
Were the outcome measures complete?	**Yes**	No	Unclear	N/A
Was follow-up time sufficient?	Yes	No	Unclear	**N/A**
Were multiple explanatory variables considered in the analysis?	Yes	No	**Unclear**	N/A
Were the analytical methods appropriate?	**Yes**	No	Unclear	N/A
Was the precision of the association given or calculable? Is association meaningful?	Yes	No	**Unclear**	N/A
Are the study results internally valid?	++	**+**	-	
Are the study results applicable to the UK?	++	**+**	-	

Study: Stommel M, Schoenborn CA. Variations in BMI and prevalence of health risks in diverse racial and ethnic populations. Obesity. 2010; 18(9):1821-6. Refid 203.	Question no: 4			
Is the source population or source area well described?	Yes	No	**Unclear**	N/A
Is the eligible population or area representative of the source population or area?	Yes	No	**Unclear**	N/A
Do the selected participants or areas represent the eligible population or area?	Yes	No	**Unclear**	N/A
Were likely confounding factors identified and controlled?	**Yes**	No	Unclear	N/A
Is the setting applicable to the UK?	Yes	No	**Unclear**	N/A
Were the outcome measures and procedures reliable?	Yes	No	**Unclear**	N/A
Were the outcome measures complete?	Yes	No	**Unclear**	N/A
Was follow-up time sufficient?	Yes	No	Unclear	**N/A**
Were multiple explanatory variables considered in the analysis?	**Yes**	No	Unclear	N/A
Were the analytical methods appropriate?	**Yes**	No	Unclear	N/A
Was the precision of the association given or calculable? Is association meaningful?	Yes	**No**	Unclear	N/A
Are the study results internally valid?	++	**+**	-	
Are the study results applicable to the UK?	++	**+**	-	

Study: Taylor HA Jr, Coady SA, Levy D et al. Relationships of BMI to cardiovascular risk factors differ by ethnicity. Obesity. 2010; 18(8): 1638-45. Refid 63.	Question no: 4			
Is the source population or source area well described?	**Yes**	No	Unclear	N/A
Is the eligible population or area representative of the source population or area?	Yes	No	**Unclear**	N/A
Do the selected participants or areas represent the eligible population or area?	Yes	No	**Unclear**	N/A
Were likely confounding factors identified and controlled?	**Yes**	No	Unclear	N/A
Is the setting applicable to the UK?	**Yes**	No	Unclear	N/A
Were the outcome measures and procedures reliable?	**Yes**	No	Unclear	N/A
Were the outcome measures complete?	**Yes**	No	Unclear	N/A
Was follow-up time sufficient?	Yes	No	Unclear	**N/A**
Were multiple explanatory variables considered in the analysis?	Yes	No	**Unclear**	N/A
Were the analytical methods appropriate?	**Yes**	No	Unclear	N/A
Was the precision of the association given or calculable? Is association meaningful?	**Yes**	No	Unclear	N/A
Are the study results internally valid?	**++**	+	-	
Are the study results applicable to the UK?	++	**+**	-	

Study: Nyamdorj R, Pitkaniemi J, Tuomilehto J et al. Ethnic comparison of the association of undiagnosed diabetes with obesity. Int J Obes (Lond). 2010;34(2):332-9. Refid 403.	Question no: 4			
Does the review address an appropriate, relevant and clearly-focused question?	**Yes**	No	Unclear	N/A
Does the review include the types of study/ies relevant to the key research questions?	**Yes**	No	Unclear	N/A
Is the literature search sufficiently rigorous to identify all the relevant studies?	Yes	No	Unclear	**N/A**
Is the study quality of included studies appropriately assessed and reported?	Yes	**No**	Unclear	N/A
Is an adequate description of analytical methodology used included, and are the methods used appropriate to the question?	**Yes**	No	Unclear	N/A
Summary quality score	++	**+**	-	
Are the review results/findings applicable to the UK?	++	**+**	-	

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Chiu et al, 2011 **Study ID:** Refid 342 **Data source:** Statistics Canada's 1996 National Population Health Survey, Canadian Community Health Survey **Full Citation:** Chiu M, Austin PC, Manuel DG et al. Deriving ethnic-specific BMI cutoff points for assessing diabetes risk. Diabetes Care. 2011; 34:1741-8. **Sources of funding:** Heart and Stroke Foundation of Ontario, Canadian Institutes of Health Research, Ontario Ministry of Health and Long-Term Care **Competing interests:** None	**Study Design:** Cohort **Question/objective:** To compare incidence rates of diabetes across different ethnic groups and identify risk-equivalent cutpoints for diabetes risk. **Years of study:** 1996 to 2009 **Mean follow-up:** 6 years **Response rate:** 75.1% to 94.4% (survey response) **Missing data:** Similar across ethnic groups (2.0% to 3.5%)	**Country trial conducted in:** Canada **Ethnicity:** South Asian Black Chinese White **Source of participants:** Population **Number:** 57,210 (total) South Asian - 1,001 Black - 747 Chinese - 866 White - 57,210 **Reported eligibility criteria:** Inclusion Aged ≥30y Ontario, Canada residents White, South Asian, Chinese or Black ethnicity Exclusion Prevalent diabetes, heart disease, stroke, cancer	**Gender (% male):** South Asian - 56.8% Black - 50.1% Chinese - 51.0% White - 49.1% **Age (y), mean (SD):** South Asian - 43.7 Black - 44.5 Chinese - 44.59 White - 48.5 **Baseline BMI (kg/m^2) and WC (cm), mean (SD):** South Asian - 24.6 Black - 26.1 Chinese - 22.6 White - 26.1 **Co-morbidity:** History of hypertension South Asian - 17.1% Black - 20.8% Chinese - 15.2% White - 20.4% **Physical disease/health status:** Current Smoker South Asian - 11.9% Black - 14.9% Chinese - 11.3% White - 26.4% Mean alcoholic drinks/week South Asian - 1.1 Black - 1.3 Chinese - 0.7 White - 3.9 ≤15 min physical activity per day South Asian - 78.8% Black - 70.7% Chinese - 78.9% White - 65.0%	**Exposure(s)/Index Test:** BMI **Objective exposure measurement/how measured:** Self-reported **Outcome(s)/Reference Test:** Diabetes (incident) **Objective outcome measurement/how measured:** Diabetes diagnosis ascertained by the population-based Ontario Diabetes Database **Other relevant outcomes:** None **Adjustments:** Age, sex, BMI-ethnicity interaction, age-BMI interaction, income adequacy, survey year, and urban vs. rural dwelling	**Study authors' conclusions:** There was a strong gradient in risk of incident diabetes with BMI. At BMI ranges thought to confer increasing but acceptable risk among Asian populations (based on WHO Asian specific BMI categories), the incidence of diabetes was significantly higher in South Asian compared to white participants. **Additional Notes:** BMI calculated from self-reported height and weight; may misclassify exposure. **Comments on statistical analysis, validity and applicability:** * based on overlapping CIs, Asians have significantly high incidence of diabetes than whites at all BMI definitions for risk

<table>
<tr><th colspan="6">Results</th></tr>
<tr><td>Chiu, 2011
Refid 342
Canada</td><td>Incidence rates per 1,000 person years (95% CI if reported) by BMI category</td><td>Risk equivalent BMI values (kg/m²) for 30 kg/m² in white subjects</td><td>HR (95% CI) for incident diabetes compared to Whites</td><td>Risk equivalent WC values (cm) for European 102 cm and 88 cm</td><td>Incidence rates per 1,000 person years (95% CI if reported) by other categories</td></tr>
<tr><td></td><td>Diabetes
<u>South Asian</u>
<18.5: 1.8 (0.0 to 7.3)
18.5 to <25: 12.1 (7.8 to 16.9)*
25 to <30: 27.7 (17.1 to 38.7)*
≥30: 76.6 (49.0 to 110.3)*

18.5 to <23: 11.6 (6.0 to 17.8)*
23 to <27.5: 20.2 (13.1 to 27.8)*
≥27.5: 44.9 (28.1 to 63.9)*

<u>Black</u>
<18.5: 0.0 (0.0 to 0.0)
18.5 to <25: 8.4 (3.6 to 14.6)
25 to <30: 18.6 (10.6 to 27.1)
≥30: 38.0 (18.0 to 61.8)

18.5 to <23: 7.3 (1.1 to 16.9)
23 to <27.5: 14.1 (8.6 to 20.2)*
≥27.5: 28.9 (17.0 to 42.9)

<u>Chinese</u>
<18.5: 0.0 (0.0 to 0.0)
18.5 to <25: 6.8 (3.3 to 10.6)
25 to <30: 19.5 (9.3 to 34.2)
≥30: 79.6 (17.6 to 157.7)

18.5 to <23: 3.7 (1.1 to 6.4)
23 to <27.5: 16.8 (8.4 to 25.2)*
≥27.5: 30.9 (10.9 to 52.6)*

<u>White</u>
<18.5: 3.3 (1.2 to 5.6)
18.5 to <25: 4.1 (3.7 to 4.5)
25 to <30: 10.0 (9.3 to 10.8)
≥30: 25.6 (23.5 to 27.4)

18.5 to <23: 3.1 (2.7 to 3.6)
23 to <27.5: 6.9 (6.4 to 7.6)
≥27.5: 19.0 (17.9 to 20.0)</td><td>Diabetes
White: 30
Black: 26
Chinese: 25
South Asian: 24</td><td>Adjusted for age
<u>Overall</u>
South Asian - 2.63 (1.99 to 3.27)
Black - 2.04 (1.50 to 2.68)
Chinese - 1.15 (0.73 to 1.68)
White - 1.0 (reference)

<u>Male</u>
South Asian - 2.73 (1.83 to 3.69)
Black - 1.53 (0.89 to 2.23)
Chinese - 1.11 (0.61 to 1.78)
White - 1.0 (reference)

<u>Female</u>
South Asian - 2.48 (1.62 to 3.42)
Black - 2.75 (1.71 to 3.94)
Chinese - 1.19 (0.53 to 1.89)
White - 1.0 (reference)

Adjusted for BMI
South Asian - 3.40 (2.58 to 4.24)
Black - 1.99 (1.39 to 2.71
Chinese - 1.87 (1.16 to 2.60)
White - 1.0 (reference)

<u>Male</u>
South Asian - 3.78 (2.59 to 5.08)
Black - 1.65 (0.87 to 2.56)
Chinese - 1.76 (0.97 to 2.83)
White - 1.0 (reference)

<u>Female</u>
South Asian - 3.01 (1.99 to 4.20)
Black - 2.40 (1.47 to 3.52)
Chinese - 2.00 (0.88 to 3.18)
White - 1.0 (reference)</td><td>N/A</td><td>Diabetes
<u>Non-immigrant</u>
South Asian - 30.8 (3.4 to 79.5)
Black - 8.1 (0.7 to 19.4)
Chinese - 8.6 (0.9 to 21.7)
White - 8.9 (8.5 to 9.4)

<u>Immigrant</u>
South Asian - 20.5 (15.9 to 25.1)
Black - 17.2 (12.7 to 22.8)
Chinese - 9.4 (5.8 to 13.5)
White - 11.7 (10.4 to 13.0)

<u><10y in Canada</u>
South Asian - 17.5 (11.3 to 25.5)
Black - 14.3 (5.5 to 26.2)
Chinese - 2.6 (0.7 to 5.0)
White - 4.0 (2.2 to 6.4)

<u>10y to <30y in Canada</u>
South Asian - 22.6 (14.8 to 30.2)
Black - 17.4 (10.7 to 25.3)
Chinese - 10.7 (5.4 to 16.6)
White - 8.9 (6.8 to 11.0)

<u>≥30y in Canada</u>
South Asian - 23.8 (10.1 to 41.8)
Black - 19.4 (8.5 to 34.3)
Chinese - 29.9 (8.8 to 57.4)
White - 14.9 (13.2 to 16.7)</td></tr>
</table>

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Cameron et al, 2010 **Study ID:** Refid 442 **Data source:** Mauritius non-communicable disease survey, Australian Diabetes, Obesity and Lifestyle study (AusDiab) **Full Citation:** Cameron AJ, Sicree RA, Zimmet PZ et al. Cut-points for waist circumference in Europids and South Asians. Obesity. 2010; 18(10):2039-2046. **Sources of funding:** National Heart Foundation of Australia **Competing interests:** None	**Study Design:** Cohort **Question/objective:** To assess the appropriateness of high waist circumference cut-points for Europids compared to South Asian populations in terms of Type 2 Diabetes risk **Years of study:** 1987 to 1992 (Mauritius) 1999 to 2005 (AusDiab) **Mean follow-up:** Not reported **Response rate:** 80% (Mauritius) 55% (AusDiab) **Missing data:** 74% follow-up (Mauritius) 59% follow-up (AusDiab) Participants with missing data at baseline or follow-up were excluded	**Country trial conducted in:** Mauritius and Australia **Ethnicity:** South Asian Caucasian (Europid ancestry) **Source of participants:** Population **Number:** 7,729 (total) South Asian - 2,214 Caucasian - 5,515 **Reported eligibility criteria:** Inclusion Aged 25 or older Enrolled in AusDiab or Mauritius non-communicable disease survey Exclusion Baseline diabetes Pregnant women Participants with missing data (WC or diabetes status at baseline or follow-up)	**Gender (% male):** Mauritius: 45.9% AusDiab: 45.5% **Age (y), mean (SD):** Mauritius: 40.7 (12.0) AusDiab: 51.1 (12.6) **Baseline BMI (kg/m^2) and WC (cm), mean (SD):** BMI Mauritius: 23.3 (4.2) AusDiab: 26.8 (4.6) WC Mauritius: 77.2 (10.1) AusDiab: 90.1 (13.4) **Co-morbidity:** Not reported **Physical disease/health status:** Current Smokers Mauritius - 26.8% AusDiab - 11.4%	**Exposure(s)/Index Test:** WC **Objective exposure measurement/how measured:** Mauritius: narrowest point between the xiphisternum and umbilicus AusDiab: midway between lower border of ribs and ilicac crest **Outcome(s)/Reference Test:** Diabetes **Objective outcome measurement/how measured:** Diabetes defined by 2006 WHO criteria: FPG ≥126mg/dL (7.0mmol/L), 2-hour plasma glucose ≥200mg/dL (11.1mmol/L) **Other relevant outcomes:** None **Adjustments:** Stratified by population and gender, adjusted for age and age squared	**Study authors' conclusions:** South Asian participants exhibited high risk for diabetes at WC values considered normal; Recommended WC cut-points in South Asians should be lowered. **Additional Notes:** To account for difference in WC measurement methods, researchers added 1.5cm to the measurements of South Asian males and 2.7cm to the measurements of South Asian females, based on the results of a previous study of variation in mean WC values using different measures in a multi-ethnic population. **Comments on statistical analysis, validity and applicability:** Estimated diabetes incidence compared for two different time periods between populations.
Results					
Cameron, 2010 **Refid 442** **Mauritius and Australia**	**Incidence (95% CI if reported) by BMI**	**Risk equivalent BMI values (kg/m^2) for European 25 kg/m^2 and 30 kg/m^2**	**Incidence (95% CI if reported) by WC**	**Risk equivalent WC values (cm) for European 102 cm and 88 cm**	**Other:**
	N/A	N/A	N/A	**Graph only**	

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Pan et al, 2004 Study ID: Refid 440 Data source: Nutrition and Healthy Survey in Taiwan (NAHSIT), United States National Health and Nutrition Examination Survey (NHANES III) Full Citation: Pan W-H, Flegal KM, Chang H-Y et al. Body mass index and obesity-related metabolic disorders in Taiwanese and US whites and blacks: implications for definitions of overweight and obesity for Asians. Am J Clin Nutr. 2004; 79(1): 31-9. Sources of funding: Republic of China Department of Health Competing interests: Not reported	Study Design: Cross sectional Question/objective: To compare the relationship between BMI and Type 2 Diabetes among ethnicities Years of study: 1993 to 1996 (Taiwan) 1988 to 1994 (USA) Response rate: 74% (Taiwan) Not reported (USA) Missing data: 52.2% complete data (Taiwan) Not reported (USA)	Country trial conducted in: Taiwan and USA Ethnicity: Chinese Black White Source of participants: Population Number: 14,295 (total) Chinese - 3,047 Black - 4,542 White - 6,706 Reported eligibility criteria: Inclusion Aged 20 years or older Enrolled in NAHSIT or NHANES III Exclusion BMI ≤16 kg/m2 or ≥40 kg/m2	Gender (% male): Chinese: 51.0% Black: 45.1% White: 48.6% Age (y), mean (SD): Not reported Baseline BMI (kg/m2) and WC (cm), median (SD): BMI males Chinese: 22.8 Black: 25.8 White: 26.0 BMI females Chinese: 22.4 Black: 27.6 White: 24.6 Co-morbidity: Hypertension Chinese: 23.3% Black: 30.7% White: 25.0% Hypercholesterolemia Chinese: 11.6% Black: 18.1% White: 22.4% Hypertriglyceridemia Chinese: 10.9% Black: 7.0% White: 16.8% Physical disease/health status: Not reported	Exposure(s)/Index Test: BMI Objective exposure measurement/how measured: Taiwan: weight measured to the nearest 0.1kg, height to the nearest 1mm in light clothing or an examination gown. USA: not reported Outcome(s)/Reference Test: Diabetes Objective outcome measurement/how measured: Taiwan: Fasting blood glucose concentration ≥6.1 mmol/L USA: FPG ≥7.0mmol/L Other relevant outcomes: None Adjustments: Stratified by BMI and ethnicity, age- and sex- standardised	Study authors' conclusions: A lower BMI cutoff value among Asians may be appropriate, but it is not clear where to set the value. Additional Notes: Taiwanese sample had a lower proportion of participants over the age of 65 years than the USA sample. Comments on statistical analysis, validity and applicability: Estimated diabetes incidence compared for two different time periods between populations.
Results					
Pan, 2004 **Refid 440** **Taiwan and USA**	**Prevalence (95% CI if reported) by BMI**	**Risk equivalent BMI values (kg/m2) for European 25 kg/m2 and 30 kg/m2**	**Prevalence (95% CI if reported) by WC**	**Risk equivalent WC values (cm) for European 102 cm and 88 cm**	**Other:**
	N/A	Graph only	N/A	N/A	

Characteristics

Study	Methods	Population	Participants (baseline)	Exposures and Outcomes	Comments
Author, Year: Stevens et al, 2002 Study ID: Refid 441 Data source: Cancer Prevention Study I (CPS-I), Atherosclerosis Risk in Communities Study (ARIC) Full Citation: Stevens J, Juhaeri JC, and Jones DW. The effect of decision rules on the choice of body mass index cutoff for obesity: examples from African American and white women. Am J Clin Nutr. 2002; 75(6):986-92. Sources of funding: American Heart Association Competing interests: Not reported	Study Design: Cohort Question/objective: To estimate the BMI value in black women that is associated with a risk equivalent to a BMI of 30 kg/m2 among white women. Years of study: 1960 to 1972 (CPS-I) 1987 to 1989 (ARIC) Mean follow-up: Not reported Response rate: Not reported Missing data: 9.6% (CPS-I) 7.2% (ARIC) Participants with missing data at were excluded from analysis	Country trial conducted in: USA Ethnicity: Black White Source of participants: Population and community Number: CPS-I Black - 3,160 White - 193,135 ARIC Black - 2,304 White - 5,715 Reported eligibility criteria: Inclusion Aged 45 to 64 at baseline Female Exclusion Previous heart disease, stroke, or cancer at baseline Death within first year of follow-up period Pregnant at baseline Participants with missing data (WC or diabetes status at baseline or follow-up) Involuntary weight loss ≥4.5 kg in the previous two years Current and former smokers	Gender (% male): 0% Age (y), mean (SD): CPS-I: Black: 53.0 (5.4) White: 53.6 (5.5) ARIC: Black: 53.2 (5.7) White: 54.0 (5.7) Baseline BMI (kg/m2) and WC (cm), mean (SD): BMI CPS-I: Black: 28.0 (5.5) White: 25.0 (4.2) ARIC: Black: 30.8 (6.1) White: 26.6 (5.1) Co-morbidity: Not reported Physical disease/health status: Current or former smokers Black: NR (CPS-I), 41.2% (ARIC) White: NR (CPS-I), 48.6% (ARIC) Current drinkers Black: 13.3% (CPS-I), 20.6% (ARIC) White: 18.8% (CPS-I), 60.1% (ARIC) Low or Moderate Physical Activity Black: 82.8% (CPS-I), 95.4% (ARIC) White: 90.3% (CPS-I), 87.7% (ARIC)	Exposure(s)/Index Test: BMI Objective exposure measurement/how measured: CPS-I: self-reported height and weight (without shoes and in light clothing) ARIC: height measured to nearest cm, using wall mounted metal ruler; weight assessed in scrub suit without shoes, using beam balance Outcome(s)/Reference Test: Diabetes Objective outcome measurement/how measured: FPG ≥126mg/dL (6.99mmol/L), non-fasting plasma glucose ≥200mg/dL (11.1mmol/L), self-reported physician diagnosis or self-reported diabetes medication use Other relevant outcomes: All cause mortality Adjustments: Diabetes analysis (ARIC): smoking status, study centre, age, education, physical activity and alcohol consumption Mortality analysis (CPS-I): age, education, physical activity, alcohol consumption	Study authors' conclusions: Absolute risk equivalent cut-off values vary depending on the outcome of interest. Additional Notes: Self-reported height and weight used to calculate BMI, may misclassify exposure value. Self-reported diabetes diagnosis or medication use included as diabetes diagnostic criteria, which may misclassify cases compared to current UK practice. Comments on statistical analysis, validity and applicability: Incidence rate, rate ratio and rate difference (using 21.0 kg/m2 as the reference) were calculated and used to estimate the risk associated with a BMI of 30 kg/m2 among white women. Analysis based on 20 to 50 year old data, may reduce applicability to current UK practice. Association between BMI and ACM among black women was not statistically significant at p<0.05.

Results

Stevens, 2002 **Refid 441** **USA**	**Incidence rate among white women at 30 kg/m2**	**Risk equivalent BMI values (kg/m2) for 30 kg/m2 - diabetes**	**Incidence (95% CI if reported) by WC**	**Risk equivalent WC values (cm) for European 102 cm and 88 cm**	**Other:**
	Diabetes: graph only ACM: 8.04/1,000 person-years	**Incidence rate: 28 kg/m2**	N/A	N/A	**Incidence rate: 18 kg/m2*** *** association not significant**

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Stevens et al, 2008 Study ID: Refid 202 Data source: People's Republic of China Study, Atherosclerosis Risk in Communities Study Full Citation: Stevens J, Truesdale KP, Katz EG et al. Impact of body mass index on incident hypertension and diabetes in Chinese Asians, American Whites and American Blacks. Am J Epidemiol. 2008; 167:1365-74. Sources of funding: US National Institutes of Health Competing interests: None	Study Design: Cohort Question/objective: To evaluate and compare the association of BMI with diabetes and hypertension among Asians dwelling in China and Blacks and Whites dwelling in the United States Years of study: 1983 to 1994, and 1987 to 1998 Mean follow-up: 7.9 to 8.2 years Response rate: Not reported Missing data: Not reported Participants without data on BMI at baseline, or at follow-up visits or pertinent covariates were excluded	Country trial conducted in: USA, China Ethnicity: American Blacks Chinese Asians American Whites Source of participants: Community Number: American Blacks - 3,582 Chinese Asians - 5,980 American Whites - 10,776 Reported eligibility criteria: Inclusion Ages 45 to 64 years Classified as white or black (ARIC study) Exclusion Blacks from Washington County, Maryland or Minneapolis, Minnesota (ARIC study) Missing data on BMI at baseline, or at follow-up visits or pertinent covariates	Gender (% male): 46% Age (y), mean (SD): Males Chinese Asian - 51.1 (4.0) American Blacks - 53.6 (5.9) American Whites - 54.7 (5.7) Females Chinese Asian - 50.9 (4.4) American Blacks - 53.2 (5.7) American Whites - 53.9 (5.7) Baseline BMI (kg/m2) and WC (cm), mean (SD): BMI Males Chinese Asian - 22.0 (3.3) American Blacks - 27.8 (4.9) American Whites - 27.4 (4.0) Females Chinese Asian - 22.4 (3.8) American Blacks - 30.8 (6.6) American Whites - 26.6 (5.4) Co-morbidity: Not reported Physical disease/health status: Current Smokers Male - 29.2% to 74.0% Female - 22.5% to 23.8% Current Drinkers Male - 49.9% to 69.9% Female - 3.5% to 61.1%	Exposure(s)/Index Test: BMI Objective exposure measurement/how measured: Height and weight were measured in light clothing or scrub suits without shoes, using a beam balance scale. Outcome(s)/Reference Test: Diabetes (incident) Objective outcome measurement/how measured: Diabetes defined as FPG ≥126mg/dL, Self-report of taking diabetes medication, Self-report of physician diagnosed diabetes Other relevant outcomes: None Adjustments: Sex, baseline age, education, smoking status, alcohol consumption, field centre	Study authors' conclusions: The difference in incidence of diabetes associated with BMI is greater in Chinese Asians than American Whites. Additional Notes: Diabetes assessed in part via self-report; may result in outcome misclassification. Comments on statistical analysis, validity and applicability: No sex and BMI interactions were found; both genders were combined in all further analyses. Logistic regression analysis conducted for each group. Estimated incident diabetes risk differences were adjusted to a selected common group or to the mean (where possible) in order to compared incidence and risk difference across ethnicities. Therefore, estimated probabilities were based on a non-smoker and non-drinker aged 53.2 years (mean age) for a population that was 54% female (combined samples sex distribution).

Results					
Stevens, 2008 **Refid 202** **USA, China**	**Prevalence (95% CI if reported) by BMI**	**Risk Differences (%) by BMI (kg/m2) category; 95% CI (if reported)**	**Prevalence (95% CI if reported) by WC**	**Risk equivalent WC values (cm) for European 102 cm and 88 cm**	**Other:**
	N/A	Chinese Asians <18.5: -1.6 (-24.7 to 21.5) 18.5 to <23.0: 0.0 (referent) 23.0 to <25.0: 4.9 (-30.6 to 40.4) 25.0 to <27.5: 9.7 (-57.3 to 76.6) 27.5 to <30.0: 14.5 (-94.3 to 123.3) 30.0 to <32.5: 18.9 (-186.7 to 224.5) ≥32.5: Not reported American Blacks <18.5: Not reported 18.5 to <23.0: 0.0 (referent) 23.0 to <25.0: 5.1 (-17.3 to 27.6) 25.0 to <27.5: 7.6 (-17.9 to 33.0) 27.5 to <30.0: 12.1 (-23.1 to 47.3) 30.0 to <32.5: 15.2 (-29.9 to 60.4) ≥32.5: 23.7 (-26.9 to 74.2) American Whites <18.5: 1.9 (-34.8 to 38.5) 18.5 to <23.0: 0.0 (referent) 23.0 to <25.0: 1.7 (-6.0 to 9.4) 25.0 to <27.5: 4.6 (-10.1 to 19.3) 27.5 to <30.0: 8.8 (-17.5 to 35.2) 30.0 to <32.5: 14.1 (-27.0 to 55.2) ≥32.5: 21.4 (-29.2 to 72.0)	N/A	N/A	Incidence of diabetes with BMI given in graphical format.

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Stommel et al, 2010 Study ID: Refid 203 Data source: National Health Interview Survey Full Citation: Stommel M, Schoenborn CA. Variations in BMI and prevalence of health risks in diverse racial and ethnic populations. Obesity. 2010; 18(9):1821-6. Sources of funding: Not reported Competing interests: None	Study Design: Cross sectional Question/objective: To compare the prevalence of diabetes and other conditions among different ethnic groups and examine differences in the BMI health risk relationship for small BMI increments Years of study: 1997 to 2007 Response rate: 78.3% to 87.4% over years of study Missing data: BMI values missing for 4.4% of participants	Country trial conducted in: USA Ethnicity: Black Asian Chinese Japanese, Korean, Vietnamese White Source of participants: Community Number: 337,375 (total) Black - 47,468 Asian -5,553 White - 219,521 Non-scoped - 64,833 Reported eligibility criteria: Inclusion Aged ≥18y Non-institutionalised	Gender (% male): Not reported Age (y), mean (SD): Not reported Baseline BMI (kg/m2) and WC (cm), mean (SD): Not reported Co-morbidity: Hypertension Black - 31.3% (30.6% to 31.9%) Asian -16.5% (15.3% to 17.9%) White - 25.1% (24.8% to 25.4%) CHD Black - 2.9% (2.7% to 3.1%) Asian -1.9% (1.5% to 2.3%) White - 4.4% (4.3% to 4.5%) Asthma Black - 10.7% (10.4% to 11.1%) Asian -6.1% (5.3% to 7.0%) White - 10.3% (10.2% to 10.5%) Functionally limiting arthritis Black - 10.1% (9.8% to 10.5%) Asian - 4.4% (3.7% to 5.1%) White - 11.1% (10.9% to 11.3%) Physical disease/health status: Not reported	Exposure(s)/Index Test: BMI Objective exposure measurement/how measured: Self-report of height and weight without shoes Outcome(s)/Reference Test: Diabetes Objective outcome measurement/how measured: Self report of diabetes diagnosis by a doctor Other relevant outcomes: None Adjustments: Prevalence adjusted for age, sex, education, poverty status, marital status, health insurance, urban vs. rural residency, foreign vs. domestic birth, smoking status, physical activity level and alcohol consumption	Study authors' conclusions: "Using the prevalence of five chronic conditions as the risk criterion, a categorization the BMI into normal, overweight, or obesity appears to be somewhat arbitrary, as there are no obvious BMI thresholds that divide the population into meaningful risk groups. However, for all population groups, except East Asians, a modest increased disease risk was noted for persons with a BMI <20 compared with persons with a BMI in the range of 20 - 21." Additional Notes: Exposure and outcome assessed using self-report Comments on statistical analysis, validity and applicability: Researchers applied a correction to self-reported BMI.

Results					
Stommel, 2010 Refid 203 USA	**Prevalence (95% CI if reported) by BMI**	**Risk equivalent BMI values (kg/m2) for European 25 kg/m2 and 30 kg/m2**	**Prevalence (95% CI if reported) by WC**	**Risk equivalent WC values (cm) for European 102 cm and 88 cm**	**Other:**
	Diabetes General US population <18.5: 2.7% 18.5 to <20: 2.0% 20 to <21: 1.9% 21 to <22: 2.4% 22 to <23: 2.7% 23 to <24: 3.2% 24 to <25: 3.8% 25 to <26: 4.4% 26 to <27: 4.6% 27 to <28: 5.8% 28 to <29: 7.1% 29 to <30: 7.9% 30 to <31: 7.6% 31 to <32: 9.8% 32 to <35: 11.3% 35 to <37: 14.9% 37 to <40: 16.9% ≥40: 21.5%	**Graphical only**	N/A	N/A	

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Taylor et al, 2010 Study ID: Refid 63 Data source: Framingham Heart Study (FHS), Jackson Heart Study (JHS) Full Citation: Taylor HA Jr, Coady SA, Levy D et al. Relationships of BMI to cardiovascular risk factors differ by ethnicity. Obesity. 2010; 18(8): 1638-45. Sources of funding: National Institutes of Health Competing interests: None	Study Design: Cross sectional Question/objective: To assess how obesity is associated with cardiovascular risk factors in African Americans and whites of European ancestry Years of study: 1998 to 2005 Response rate: Not reported Missing data: Participants with missing data excluded	Country trial conducted in: USA Ethnicity: Black White Source of participants: Community Number: 9,275 (total) Black - 4,030 (JHS study) White - 5,245 (FHS study) Reported eligibility criteria: Inclusion Aged 35 to 74y Enrolled in the FHS or JHS BMI of 18.5 to 50.0 kg/m2 Exclusion CVD Participants with missing data (BMI or covariates)	Gender (% male): JHS: 36% FHS: 46% Age (y), mean (SD): JHS: 54 FHS: 51 Baseline BMI (kg/m2) and WC (cm), mean (SD): Not reported Co-morbidity: Hypertension, cholesterol, and lipids reported by BMI group Physical disease/health status: Smoking and alcohol intake reported by BMI group	Exposure(s)/Index Test: BMI Objective exposure measurement/how measured: Height and weight measured in examination gowns without shoes Outcome(s)/Reference Test: Diabetes Objective outcome measurement/how measured: Diabetes defined by FPG ≥126mg/dL, or Casual PG ≥200mg/dL, or Use of insulin or oral hypoglycaemic medications at the time of examination Other relevant outcomes: None Adjustments: Age, sex, smoking status and education	Study authors' conclusions: Diabetes is more prevalent in African Americans compared to whites in all BMI categories. Additional Notes: DM defined according to insulin use; could introduce classification bias via the inclusion of Type 1 DM in the analysis. Such a misclassification could overestimate the prevalence Comments on statistical analysis, validity and applicability: Framingham Heart study comprised of mainly whites of European descent; lack of data on ethnicity within this cohort may confound comparison results. In the main publication, results presented for participants aged 34 to 54 years only. Prevalence data is available of participants aged 55-74 years old in the supplementary information.

Results					
Taylor, 2010 **Refid 63** **USA**	**Prevalence (95% CI if reported) by BMI**	**Risk equivalent BMI values (kg/m2) for European 25 kg/m2 and 30 kg/m2**	**Prevalence (95% CI if reported) by WC**	**Risk equivalent WC values (cm) for European 102 cm and 88 cm**	**Other:**
	Diabetes (participants aged 34 to 54 years) Black (JHS) 18.5 to 24.99: 3.2% 25 to 29.99: 6.2% 30 to 34.99: 13.6% 35 to 50: 17.2% White (FHS) 18.5 to 24.99: 0.5% 25 to 29.99: 2.2% 30 to 34.99: 3.9% 35 to 50: 14.8% Diabetes (participants aged 55 to 74 years) Black (JHS) 18.5 to 24.99: 9.8% 25 to 29.99: 20.0% 30 to 34.99: 25.8% 35 to 50: 33.8% White (FHS) 18.5 to 24.99: 4.0% 25 to 29.99: 8.3% 30 to 34.99: 15.4% 35 to 50: 30.5%	N/A	N/A	N/A	**OR (95% CI) for diabetes (participants aged 34 to 54 years)** **Black (JHS)** **18.5 to 24.99: 1.0 (reference)** **25 to 29.99: 1.93 (0.93 to 4.01)** **30 to 34.99: 4.49 (2.22 to 9.08)** **35 to 50: 6.51 (3.22 to 13.16)** **White (FHS)** **18.5 to 24.99: 1.00 (reference)** **25 to 29.99: 3.59 (1.55 to 8.34)** **30 to 34.99: 6.32 (2.65 to 15.09)** **35 to 50: 27.72 (12.36 to 62.19)**

Characteristics					
Study	**Methods**	**Population**	**Participants (baseline)**	**Exposures and Outcomes**	**Comments**
Author, Year: Nyamdorj, 2010b Study ID: Refid 403 Data source: Diabetes Epidemiology: Collaborative Analysis of Diagnostic Criteria in Asia (DECODA), and Diabetes Epidemiology: Collaborative Analysis of Diagnostic Criteria in Europe (DECODE) Full Citation: Nyamdorj R, Pitkaniemi J, Tuomilehto J et al. Ethnic comparison of the association of undiagnosed diabetes with obesity. Int J Obesity. 2010; 34:332-9. Sources of funding: Finnish Academy, DPPH Competing interests: None	Study Design: Meta-analysis of cross sectional data Question/objective: To determine the prevalence of undiagnosed diabetes in several ethnic groups given the same level of BMI and WC Years of study: Not reported Response rate: Not reported Missing data: Not reported	Country trial conducted in: Various (China, Japan, India, Mauritius, Cyprus, Finland, Italy, Spain, Sweden, Netherlands, UK) Ethnicity: South Asian Indian Chinese European Source of participants: Not reported Number: 54,467 from 30 studies Reported eligibility criteria: Inclusion Aged ≥30y Cohorts using BMI, WC, WHR and/or WSR measures for obesity Data on FPG and 2h PG Exclusion Previously diagnosed diabetes	Gender (% male): 45.0% Age (y), mean (SD): Indian: 43 to 47 (mean range) European: 47 to 62 (mean range) Chinese: 46 to 58 (mean range) Baseline BMI (kg/m2) and WC (cm), mean (SD): BMI Male Indian: 22.0 to 23.3 (mean range) European: 25.5 to 27.9 (mean range) Chinese: 24.3 to 26.6 (mean range) Female Indian: 23.7 to 24.5 (mean range) European: 25.2 to 28.1 (mean range) Chinese: 24.3 to 26.3 (mean range) WC Male Indian: 81.2 to 87.7 (mean range) European: 91.4 to 98.4 (mean range) Chinese: 83.5 to 89.9 (mean range) Female Indian: 77.5 to 84.4 (mean range) European: 77.6 to 86.9 (mean range) Chinese: 76.6 to 83.4 (mean range) Co-morbidity: Not reported Physical disease/health status: Not reported	Exposure(s)/Index Test: BMI, WC Objective exposure measurement/how measured: Waist circumference measured halfway between lower rib margin and iliac crest in most studies, 1 study measured WC at the umbilicus and 1 study measured halfway between the umbilicus and xyphoid process. Height and weight assessment methods not reported Outcome(s)/Reference Test: Diabetes Objective outcome measurement/how measured: Diabetes defined as FPG ≥7.0mmol/L or 2h OGTT PG ≥11.1mmol/L Other relevant outcomes: None Adjustments: Stratified by sex, adjusted for age, study	Study authors' conclusions: At the same BMI or WC levels, undiagnosed diabetes was most prevalent in Indians, least prevalent in Europeans and intermediate in Chinese. Additional Notes: Diabetes diagnostic criteria in line with current ADA and WHO/IDF guidelines. Comments on statistical analysis, validity and applicability: BMI categories defined by 1 unit (kg/m-2) intervals, WC categories defined by 3 (cm) unit intervals. Asians and Europeans had data for different BMI and WC ranges due to data availability (Asians: ≤18kg/m2 to ~31kg/m2 and ~67cm to ~100cm; Europeans ~21 kg/m2 to ~34 kg/m2 and ~67cm to ~112cm.
Results					
Nyamdorj, 2010b **Refid 403** **Various**	**Prevalence (95% CI if reported) by BMI**	**Risk equivalent BMI values (kg/m2) for European 25 kg/m2 and 30 kg/m2**	**Prevalence (95% CI if reported) by WC**	**Risk equivalent WC values (cm) for European 102 cm and 88 cm**	**Other:**
	Graph only, not extractable data	Graph only, not extractable data	Graph only, not extractable data	Graph only, not extractable data	