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Trends in general and abdominal obesity in South African adults, 1998 - 2017: A joint analysis of nine population surveys

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Background. Obesity, a health condition characterised by abnormal accumulation of body fat, is a major public health problem, with the number of affected individuals forecasted to rise sharply worldwide. Local epidemiological data are needed to understand the epidemic's specific characteristics and to implement effective evidence-based prevention strategies.
Objective. To provide insight into the South African (SA) obesity epidemic by analysing trends in the prevalence of general and abdominal obesity between 1998 and 2017.
Methods. Harmonised data on 134 029 adults (aged ≥18 years) from nine population surveys were analysed. For each survey dataset, the population distribution of body mass index (BMI), waist circumference (WC) and waist-to-height ratio (WHtR) was estimated, along with the prevalence of obesity and abdominal obesity according to standard epidemiological definitions. Metaregression models were fitted to estimate and compare the average rates of change of the multiple obesity indicators during the study period, for the whole population and by sex, population group, province of residence and geographical type (urban v. rural).
Results. Among women, the distribution of BMI, WC and WHtR showed a significant rightward shift between 1998 and 2017, with increases in median values of 1.38 (95% confidence interval (CI) 0.91 - 1.84) kg/m^2/decade for BMI, 4.04 (1.27 - 6.82) cm/decade for WC and 0.03 (0.01 - 0.04) units/decade for WHtR. The prevalence of obesity rose sharply, from 29.5% (28.1 - 30.8%) in 1998 to 42.7% (41.0 - 44.4%) in 2017. The prevalence of WC-defined and WHtR-defined abdominal obesity increased from 60.0% (58.6 - 61.3%) to 77.2% (76.0 - 78.4%), and from 62.8% (61.4 - 64.2%) to 78.7% (77.4 - 80.0%), respectively. Among men, changes in the distribution were modest and median trends not statistically significant, at 0.1 (–0.27 - 0.47) kg/m^2/decade for BMI, 1.19 (–0.48 - 2.87) cm/decade for WC and 0.01 (–0.01 - 0.02) units/decade for WHtR. Obesity prevalence rose from 10.1% (8.9 - 11.3%) in 1998 to 12.1% (10.7 - 13.4%) in 2017, WC-defined abdominal obesity from 21.6% (19.8 - 23.4%) to 26.4% (24.3 - 28.4%) and WHtR-defined abdominal obesity from 39.7% (37.8 - 41.7%) to 42.8% (40.6% - 45.0%). The prevalence of both general and abdominal obesity also differed across geographical type, province and population group, with a disproportionately rapid increase among groups and areas that initially exhibited lower prevalence.
Conclusion. Between 1998 and 2017, the prevalence of both general and abdominal obesity in the SA adult population rose substantially. Evidence-based prevention efforts and policy strategies are urgently needed to curb the growing burden, especially among women.

Keywords: body mass index, waist circumference, waist-to-height ratio, obesity, abdominal obesity, prevalence trend, Africa

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Obesity, a chronic health condition characterised by abnormal or excessive accumulation of body fat that presents a risk to health,[1] is a major global public health problem.[2] Obesity significantly increases the risk of developing a host of pathological conditions, including type 2 diabetes, hypertension, cardiovascular disease, chronic kidney disease, cirrhosis and various types of cancers.[3-8] Increased adiposity also correlates with adverse psychological, social and economic outcomes.[9-11] The Global Burden of Disease study estimated that excessive accumulation of body fat affected 2.11 billion adults in 2021 and was responsible for >3.7 million deaths and 128 billion disability-adjusted life years.[2,12] Between 1990 and 2021, the number of affected individuals increased across all world regions, and is projected to rise further in the following decades, reaching 3.8 billion (95% uncertainty interval, 3.4 - 4.0) by 2050, over half of the estimated global adult population.[2] These alarming statistics highlight the urgent need for robust prevention strategies to address the obesity epidemic. This requires strong local epidemiological data to understand the epidemic's specific characteristics and progression.

The diagnosis of obesity requires an overall evaluation of the present or potential effects that excess body fat accumulation may have on health.[13,14] However, in epidemiological research, where neither an individual clinical evaluation of the study participants nor the direct measurement of body fat distribution is usually feasible, the identification of obesity relies on a series of indices based on anthropometric measurements.[15] Body mass index (BMI, defined as body weight in kilograms divided by the squared height in metres) is the most widely used of these indices, with a large number of studies indicating that high BMI is an independent risk factor for multiple diseases and all-cause mortality.[16,17] BMI, however, can only provide an approximate measure of total adiposity (general obesity): it is unable to capture the regional distribution of body fat.[18] Other anthropometric indices – such as waist circumference (WC), waist-

to-hip ratio (WHR) and waist-to-height ratio (WHtR), alone or in combination with BMI – perform better in identifying excessive fat accumulation in the abdominal area (abdominal obesity).[15] There is substantial evidence to indicate that abdominal obesity is the key element in determining the health risk associated with fat accumulation.[19-22]

In South Africa (SA), national surveys have reported the prevalence of obesity defined by BMI – and, less commonly, abdominal obesity assessed using waist circumference or related indices – at various time points.[23-32] However, a comprehensive analysis of how general and abdominal obesity have changed over time, both in the overall population and within key demographic subgroups, is still lacking.

The present study aimed to describe the trends and distribution of BMI, WC and WHtR in the SA adult population (aged ≥18 years) between 1998 and 2017, for the total population and stratified by sex, population group, province of residence and geographical type (urban v. rural).

Methods

Study design

The study undertook a joint secondary analysis of data from multiple population surveys.

Data sources

Data were collected from nine surveys, conducted at different points in time during the 20-year period spanning 1998 - 2017, on representative samples of the SA adult population: the three iterations of the SA Demographic and Health Survey (DHS),[27-29] the five waves of the National Income Dynamics Study (NIDS)[33] and the SA National Health and Nutrition Examination Survey (SANHANES).[31] All studies sampled individuals using a multilevel random sampling strategy, including clustering, stratification and unequal sampling probability across population strata. Details on the sampling strategies and realisation are provided in the technical reports cited above. Anonymised datasets originating from the NIDS, SANHANES, DHS 1998 and DHS 2016 surveys are available online.[34-41] Datasets originating from the 2003 DHS must be requested directly from the Chief Directorate of Health Information, Research, Monitoring, and Evaluation in the National Department of Health.

The analyses presented here include only data on adults according to the SA law (individuals aged ≥18 years). Before the analyses, data were made comparable across sources by standardising variable names and aligning categories and codes.

Measurements

Anthropometric indices

In all surveys, multiple measurements of weight, height and WC were taken by trained fieldworkers using standardised techniques and equipment, described in detail in the respective technical reports. After excluding measurements with implausible values (height <120 cm or >220 cm; weight <25 kg or >250 kg for women and weight <35 kg or >250 kg for men; waist circumference <30 cm or >220 cm), we considered the average of the remaining data points as the true anthropometric values. From these, we calculated the indices of interest as follows:

$$BMI = \frac{weight\ (kg)}{height\ (m^2)};\ WC = waist\ circumference\ (cm);$$
$$WHtR = \frac{waist\ circumference\ (cm)}{height\ (cm)}$$

We applied widely used – albeit far from universally accepted – cut-offs[20,42,43] to categorise the continuous indices and define a 'general obesity' variable (BMI ≥30 kg/m^2, with three subcategories: class I: BMI 30 - <35 kg/m^2, class II: 35 - <40 kg/m^2 and class III: ≥40 kg/m^2) and two 'abdominal obesity' variables based on WC (WC ≥80/94 cm for women/men) and WHtR (WHtR ≥0.5). Individuals with BMI <30 kg/m^2 were further classified as either underweight (<18.5 kg/m^2), normal weight (18.5 - <25 kg/m^2) or overweight (25 - <30 kg/m^2).

Sociodemographic variables

Sex, age in completed years, education level and racial ascription were self-reported by participants in each survey. This last followed the categorisation that originated during the apartheid regime, consisting of four socially defined groups (Asian, black African, coloured (wide grouping of people of mixed ancestry) and white). Race in this sense is closely and enduringly correlated with socioeconomic status (SES), and the population group categorisation is still used by the SA government to identify and track the progress of historically disadvantaged individuals in the post-apartheid era.[44]

As some provincial boundaries have changed between 1998 and 2017, provincial attributions included in each source dataset have been harmonised to the 2001 administrative boundaries. Where the province of residence according to the 2001 boundaries was not available but other smaller geographies were included in the datasets (e.g. municipality or census enumeration areas), these were linked to the 2001 province using the Census Spatial Geography files from Statistics South Africa (Stats SA). For the DHS 2016 dataset, the geocoded centre of the enumeration areas was mapped onto the 2001 provincial boundaries. The geographical type (urban/rural) of the areas of residence was extracted from Stats SA's classification of census enumeration areas.[45]

Statistical analyses

Sample characteristics were described by median and interquartile range for continuous variables, and frequencies for categorical measures, separately by sex.

Population estimates of sex-specific distributions of BMI, WC and WHtR for selected years were graphically illustrated using weighted Gaussian kernel density estimation.

Independently for each survey, we estimated the median values of the indicators of interest, and the distribution of their categorical versions (general and abdominal obesity variables). We conducted the estimation separately by sex, population group, province of residence and geographical type.

Linear metaregression models (weighted by the inverse variance of the survey-specific estimates) were fitted to estimate and compare the average rates of change of the indicators during the study period. In the models (and for the purpose of graphical representation), we located each estimate at the median time of data collection of the respective source survey.

Multiple imputation with chained equations was used to handle missing data, by repeating the estimation procedures for each of 30 imputed datasets and combining the results with the Rubin's rules.[46]

In the calculations, we took into account the complex sampling designs of the source surveys, including clustering, stratification and unequal sampling probabilities. Given the known inconsistencies in the population totals across surveys conducted at different time points,[47] sampling weights provided in the source surveys were recalibrated to a consistent set of population totals, by sex, age category, population group and province of residence.[48] A generalised regression estimator as implemented in the R package Survey was applied at this end.[49] *P*-values <0.05 and 95% confidence intervals (CIs) not crossing the null value are considered to indicate

statistical significance. All analyses were conducted using R statistical software v. 4.3.1 (R Foundation for Statistical Computing, Austria).

Ethical considerations

This study consisted of a secondary analysis of publicly available anonymised microdata originating from population surveys, with no additional primary data collection. All included surveys received ethical approval from the relevant bodies, and participants provided informed consent for participation. No attempt has been made to identify the individuals involved and/or to link responses across independent data sources.

Results

Sample characteristics

The total sample included 134 029 adults (79 420 women, 59.3%), with a median age of 37 years. Consistent with the country's demographic makeup,[50,51] the black African population group was the largest, comprising over three-quarters of the whole sample, followed by the coloured, white and Asian groups. Most individuals had some secondary education, with little differences across sexes. Valid measures of BMI, WC and WHtR were available for 85.6%, 86.3% and 85.7% of the sample, respectively. The majority of women were living with either overweight or obesity, and abdominal obesity according to both definitions. On the contrary, most men had a BMI, WC and WHtR in the healthy range. A more detailed description of the characteristics of the sample is shown in Table 1.

Population distribution of BMI, WC and WHtR

The sex-specific distributions of BMI, WC and WHtR for selected years are shown in Fig. 1.

Among women, the figures indicate a clear rightward shift of the distribution of all three indicators over the study period, with median values increasing on average by 1.38 (95% CI 0.91 - 1.84) kg/m^2/decade, 4.04 (1.27 - 6.82) cm/decade and 0.03 (0.01 - 0.04) units/decade for BMI, WC and WHtR, respectively. Among men, the shift appears of modest magnitude, and median trends, albeit positive, were not statistically significant at 0.1 (–0.27 - 0.47) kg/m^2/decade for BMI, 1.19 (–0.48 - 2.87) cm/decade for WC and 0.01 (–0.01 - 0.02) units/decade for WHtR. For both sexes, the 75th percentile increased at a faster rate than the median (Appendix Table S1), indicating a growing skewness of the distribution toward higher values over time.

General and abdominal obesity

Fig. 2 shows the estimated population prevalence of underweight, normal weight, overweight and general obesity during the study period, and Fig. 3 shows a breakdown of the obesity category by class. Numerical estimates are provided in Appendix Table S2.

The prevalence of obesity rose sharply among women, from 29.5% (95% CI 28.1 - 30.8%) in 1998 to 42.7% (41.0 - 44.4%) in 2017, with an average increase of 7.9%/decade (7.0 - 8.8%). The increase was mostly at the expense of the prevalence of normal weight, which showed an almost mirror-image decline, from 38.0% (36.5 - 39.5%) to 28.2% (26.5 - 29.8%). A significant increase was present across all obesity classes. The absolute prevalence of obesity and the rates of increase were substantially lower among men. In men, obesity prevalence rose from 10.1% (8.9 - 11.3%) in 1998 to 12.1% (10.7 - 13.4%) in 2017, with an average increase of 1.3%/decade (0.6 - 2.0%). The prevalence of normal weight declined slightly, from 58.0% (56.0 - 60.0%) to 56.2% (54.1 - 58.4%) in men.

The prevalence of abdominal obesity (Fig. 4 and Appendix Table S2) followed a similar pattern, with absolute values and increasing trends significantly higher in women than men. In women, the prevalence of WC-defined abdominal obesity increased by an average of 9.7%/decade (8.4 - 11.1%), from 60.0% (58.6 - 61.3%) in 1998 to 77.2% (76.0 - 78.4%) in 2017. Abdominal obesity defined based on WHtR showed a similar trend, with an average increase of 9.0%/decade (7.7 - 10.3%), from 62.8% (61.4 - 64.2%) to 78.7% (77.4 - 80.0%). Among men, the prevalence of abdominal obesity defined in terms of WC rose by an average 3.02%/decade (1.3 - 4.7%), from 21.6% (19.8 - 23.4%) to 26.4% (24.3 - 28.4%). In terms of WHtR, the average increase was 2.7%/decade (0.8 - 4.7%), from 39.7% (37.8 - 41.7%) to 42.8% (40.6 - 45.0%).

Among women, the rate of increase in abdominal obesity remained positive and statistically significant even after adjustment for the prevalence of general obesity (BMI), at 2.42%/decade (0.51 - 4.34%) and 1.98%/decade (0.13 - 3.83%) for WC and WHtR-defined abdominal obesity, respectively. Conversely, among men, adjustment for general obesity completely offset the observed positive trends in the two indicators of abdominal obesity, with adjusted rates of 0.41%/decade (–0.69 - 1.51%) and 0.19%/decade (–1.07 - 1.46%).

Sociodemographic patterns of obesity

Group-specific trends in the obesity measures are detailed in Table 2 and Appendix Figs S1 - S5.

Among women, the prevalence of general obesity increased rapidly with age in young adults (<45 years). It showed a more modest increase among middle-aged individuals aged 45 - 64 years and declined in older ages (≥65 years). The prevalence of abdominal obesity followed a similar pattern until middle age, but showed less evident signs of decline, if any, in older age groups. Within each age category, the prevalence of general obesity increased with time, with the highest rates of increase among the 65 - 74-year age group. The prevalence of abdominal obesity also increased with time across all age groups, but the rates of increase were highest among young adults (<35 years).

Among men, the prevalence of obesity increased until older age, with no evidence of decline in older ages. Rates of change over time were small, and not statistically significant until the age of 55 years. Above that age, trends were positive and of greater magnitude for all indicators, albeit not all statistically significant (Table 2 and Appendix Fig. S1 and S2).

Among women in 1998, we found the highest prevalence of general obesity in black African women (30.6%), followed by coloured and white women with similar values (27.1% and 26.3%, respectively). Asian women had the lowest prevalence (21.6%). In the following years, we observed a generalised increase across all groups, especially among Asian women, where the prevalence almost doubled. The prevalence of abdominal obesity was higher among black African and Asian women in 1998, and lowest for white women. In the following years, we observed a significant increase in all groups, with rates significantly higher among Asian and white women.

In men, the highest prevalence of central obesity across the whole period was observed among whites, with no statistical evidence of change over time. Black African and coloured men, conversely, had lower prevalences, but significant increases over the study period, with the latter almost doubling the prevalence from 9.7% in 1998 to 18% in 2017. We found no evidence of changes in the prevalence of abdominal obesity among white, Asian and black African men, while the WC-defined prevalence increased significantly (by an average 5.7 cm/decade) among coloured men (Table 2 and Appendix Fig. S3).

While the prevalence of both general and abdominal obesity was higher in urban areas, the rate of increase between 1998 and 2017 was

Table 1. Sample characteristics: unweighted numbers and weighted statistics (*N*=134 029)

Characteristic, *n* (%)*	All	Women (*n*=79 420)	Men (*n*=54 609)
Age, years, median (IQR)	35.0 (26.0 - 49.0)	36.0 (26.0 - 50.0)	34.0 (24.0 - 47.0)
Age category, years			
18 - 24	30 004 (20.8)	16 059 (19.9)	13 945 (21.7)
25 - 34	31 431 (27.6)	18 011 (26.3)	13 420 (29.0)
35 - 44	23 560 (19.8)	14 128 (19.4)	9 432 (20.2)
45 - 54	19 951 (14.2)	12 454 (14.6)	7 497 (13.7)
55 - 64	15 173 (9.3)	9 521 (9.9)	5 652 (8.7)
65 - 74	8 866 (5.2)	5 659 (5.8)	3 207 (4.4)
≥75	5 044 (3.1)	3 588 (3.9)	1 456 (2.3)
Population group			
Black African	104 897 (77.6)	62 656 (77.9)	42 241 (77.3)
Coloured	18 991 (9.2)	11 139 (9.2)	7 852 (9.2)
White	6 481 (10.4)	3 546 (10.2)	2 935 (10.6)
Asian	3 660 (2.8)	2 079 (2.7)	1 581 (3.0)
Education			
No formal schooling	14 736 (7.3)	9 990 (8.7)	4 746 (5.7)
Some/completed primary	27 463 (16.6)	16 743 (16.6)	7 319 (16.6)
Some/completed secondary	75 950 (61.3)	43 328 (59.9)	32 622 (62.8)
Any higher education	13 638 (14.5)	8 079 (14.5)	5 559 (14.5)
Other	306 (0.3)	166 (0.3)	140 (0.4)
BMI, kg/m^2, median (IQR)	25.2 (21.5 - 30.3)	27.7 (23.3 - 33.1)	22.9 (20.3 - 26.9)
BMI categories			
Underweight	7 564 (6.0)	2 854 (3.5)	4 710 (8.8)
Normal weight	47 545 (42.9)	21 479 (31.3)	26 066 (56.2)
Overweight	28 131 (25.0)	18 429 (26.8)	9 702 (22.8)
Obesity	31 390 (26.2)	26 371 (38.3)	5 019 (12.2)
WC, cm, median (IQR)	85.2 (75.5 - 98.0)	89.2 (78.0 - 101.7)	81.0 (74.0 - 93.0)
WC ≥80/94 cm (abdominal obesity)	59 525 (49.1)	49 707 (71.1)	9 818 (23.9)
WHtR, median (IQR)	0.53 (0.46 - 0.61)	0.57 (0.49 - 0.64)	0.48 (0.43 - 0.54)
WHtR ≥0.5 (abdominal obesity)	68 502 (57.5)	50 630 (72.0)	17 872 (40.8)

*Unless otherwise indicated.
n (%) = unweighted number (weighted percentage); median = weighted median; IQR = weighted interquartile range; BMI = body mass index; WC = waist circumference; WHtR = waist-to-height ratio.

consistently higher in rural areas, attenuating the difference over time (Table 2 and Appendix Fig. S4).

The prevalence of obesity increased significantly in all provinces, albeit at varying rates. Provinces with lower initial prevalences had higher rates of increase, resulting in a reduction of interprovincial differences between 1998 and 2017. The changes in prevalence ranking are shown in Appendix Fig. 6. North West and Free State provinces had the highest rates of increase, with absolute increases of 25% and 20%, respectively. At the other end, Gauteng and Mpumalanga saw the lowest growth, with absolute increases of 10% and 10.6%, respectively (Table 2 and Appendix Fig. S3). Similar patterns were observed for abdominal obesity.

Survey-specific estimates of the prevalence of general and abdominal obesity by sex, age and population group, province of residence and geographical type are detailed in Appendix Table S2.

Discussion

This joint analysis of data collected between 1998 and 2017 in representative samples of SA adults found concerning results regarding absolute prevalence and temporal trends in general and abdominal obesity, and substantial disparities among different segments of the population. The complexity of the observed patterns highlights the multifactorial nature of the obesity epidemic, driven by a complex, and not completely understood, combination of genetic, behavioural, environmental and socioeconomic factors.[52]

Our results indicate a dramatic shift in the distribution of major indicators of general and abdominal obesity among women. Median values of BMI, WC and WtHR and, more so, proportions of individuals above standard cut-offs indicating high disease risk have all significantly and consistently increased over time. The increase occurred in adult women of all age and population groups, among rural and urban residents, and across all provinces. The 2017 estimates show that almost 43% of SA adult women were living with obesity (in addition to 26% with overweight). Recently published estimates from the 2021 National Food and Nutrition Security Survey[32] (41% obesity and 27% overweight) are in agreement, and within margins of error of our findings, and provide no evidence of a trend reversal in recent years. The findings are particularly concerning because they suggest that abdominal obesity is increasing more rapidly than overall obesity, especially among young women.

The distribution of obesity indicators was remarkably different among men, with significantly lower median values and proportions above cut-offs (12.1% prevalence of general obesity in 2017), and little evidence of change over time. Notably, the modestly increasing

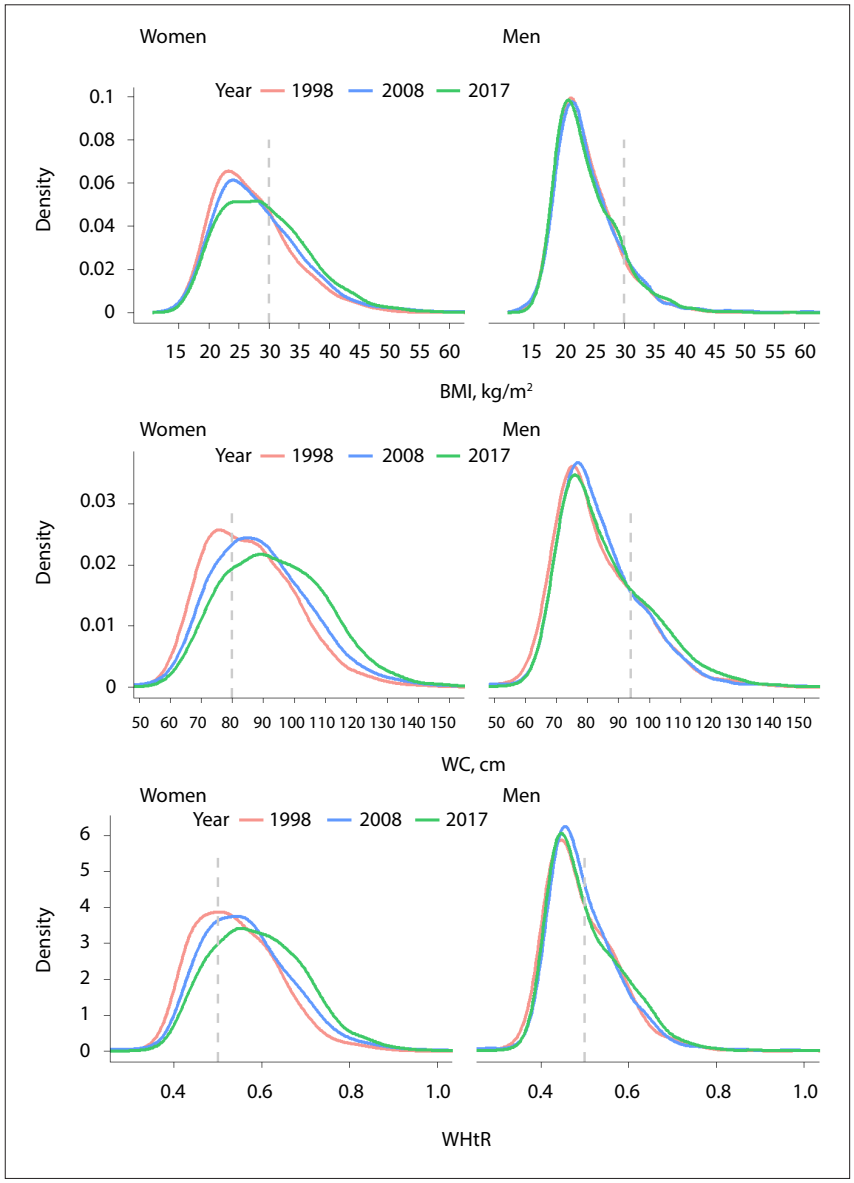

Fig. 1. Distribution of body mass index (BMI), waist circumference (WC) and waist-to-height ratio (WHtR) by sex in the South African adult population (aged ≥18 years) in 1998, 2008 and 2017. Vertical lines represent the cut-offs for the definition of obesity according to the specific indicator.

trend in WC and WHtR was driven by the increase in BMI, suggesting that unlike in women, there were no changes in body fat distribution. Sex differences in the characteristics of the obesity epidemic are a well-established finding of the international obesity literature. In all world regions and the vast majority of countries, obesity is more prevalent among women than men, with 2025 global estimates for adults aged ≥20 years at 21% for women v. 16% for men.[53] Globally, average rates of increase between 1990 and 2022 were similar in both sexes (at 2.9%/decade among women and 2.8%/decade among men), but showed large differences across world regions. Countries in sub-Saharan Africa recorded the largest sex discrepancies in favour of women, both in terms of absolute prevalence and rates of increase.[54]

SA studies have shown that the sex discrepancies in obesity begin in childhood, with obesity in girls increasing from early childhood throughout adolescence, with puberty being a particularly high-risk period.[55] In contrast, in boys, overweight and obesity are not highly prevalent by late adolescence.[55,56] In adulthood, these sex discrepancies in obesity increased with age, with the greatest increases observed in young adult women (<45 years) (Appendix Fig. S1). In contrast, in men, the prevalence of obesity only increased in the older age groups (55 - 75 years). Increased prevalence of obesity with age has been associated with worsening energy imbalance due to decreasing basal metabolic rate, loss of muscle mass and hormonal changes, together with reduced physical activity in older ages.[57,58] This adds to the physiological height loss due to disk degeneration and vertebral compression that has been shown to introduce artefactual increases in BMI at older ages.[59]

The reasons for the sex disparities in obesity are not entirely clear, but the large regional (and, often, local) differences in prevalence and trends of obesity among men and women point to a substantial role played by socioeconomic and cultural factors, in addition to biological pathways. The regional and sex-specific determinants of obesity were explored in the H3Africa AWI-Gen study, which included 10 702 participants from four sub-Saharan African countries.[60-63] In SA, the site in the study with the highest prevalence of obesity, the most consistent positive correlates of obesity in men were SES and marital status, while smoking, physical activity, alcohol intake and a positive HIV status were associated with a lower prevalence of obesity. In women, SES and marital status were associated with obesity in the rural areas only, whereas lower education in Soweto (urban) and higher education in Agincourt (rural) were associated with obesity. Consistently, and similar to the men, smoking, alcohol and a positive HIV status were inversely associated with obesity. These findings are supported by earlier studies characterising the determinants of obesity in SA.[30,64-66]

Notably, SES and cultural factors differentially impact obesity in men and women through sex-specific influences of lifestyle factors, including dietary intake, physical activity and perceptions regarding body size. For example, SES influences dietary choices, with higher income linked to weight-promoting diets such as increased consumption of meat, larger portions and more frequent fast-food intake, and lack of food security linked to poor diet quality and limited food variety.[67,68] However, a cross-sectional study in a middle-aged African cohort demonstrated that the association between nutrient patterns and obesity is sex-specific.[69] Specifically, men showed a stronger positive association between an animal protein-rich diet and higher BMI than women. In contrast, a plant-based staple dietary pattern was positively associated with central obesity in women only, with no corresponding association observed in men.[69] While meeting physical activity guidelines of at least 150 minutes per week

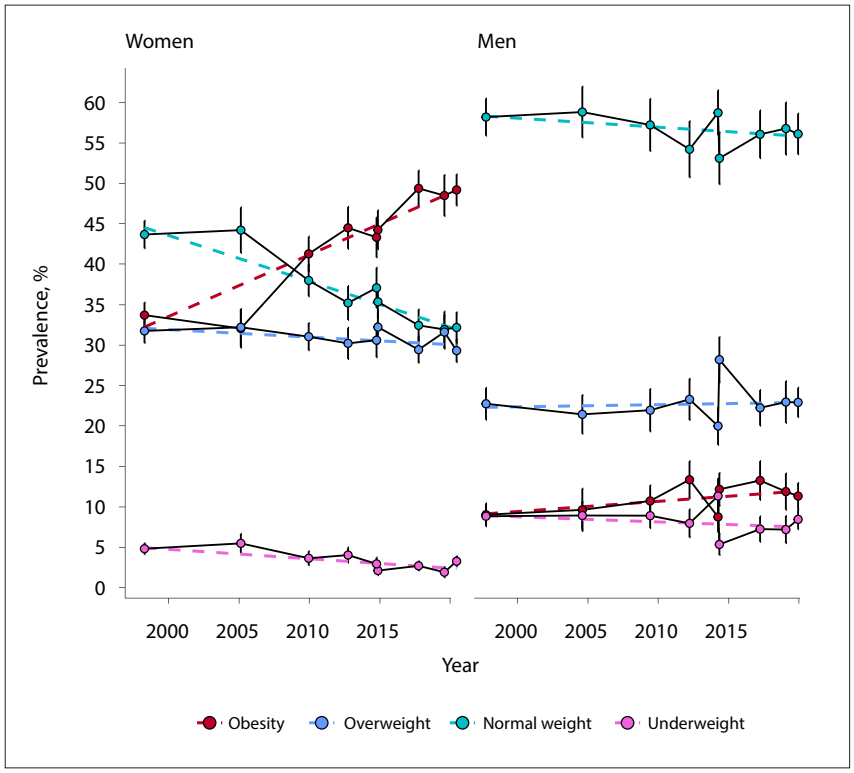

Fig. 2. Prevalence of underweight, normal weight, overweight and general obesity by sex in the South African adult population (aged ≥18 years) between 1998 and 2017.

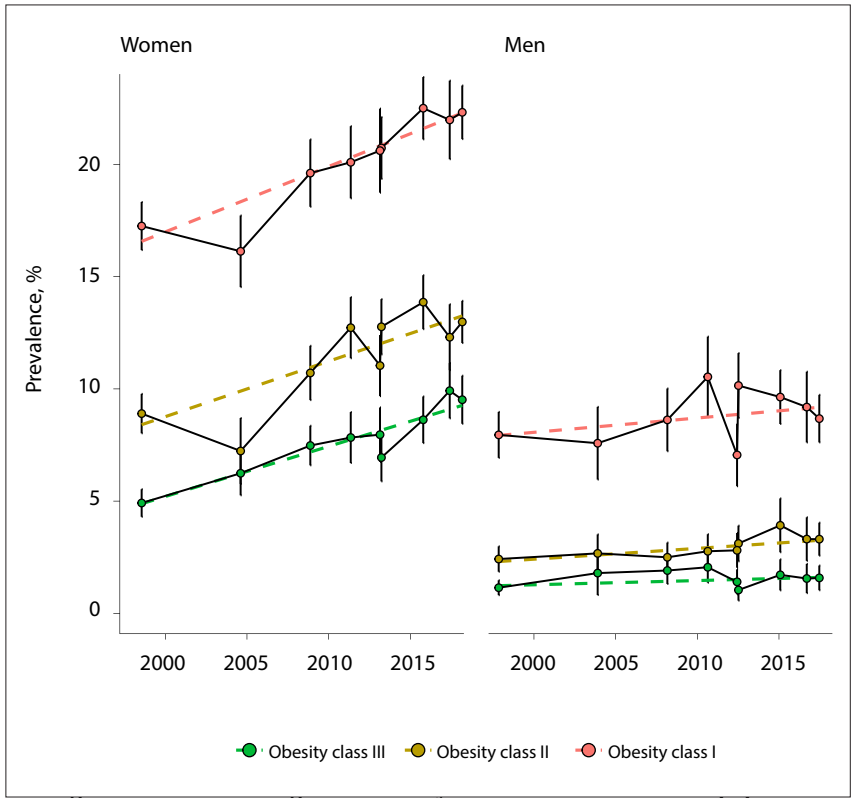

Fig. 3. Prevalence of general obesity in the South African adult population (aged ≥18 years) by sex and obesity class between 1998 and 2017. Dashed lines are inverse-variance weighted linear trends.

is associated with lower BMI in both SA men and women, overweight and obesity in SA men is associated with less time spent in moderate-to-vigorous activity, while obesity in women is associated with more time sitting or lying down.[61,70] Cultural perceptions regarding obesity and acceptance of a larger body size, particularly in African women, have also been shown to influence obesity.[71-73] While these studies provide insight into the sex-specific determinants of obesity in SA, they only account for a small proportion of the variance in obesity,[61] highlighting the need for further nutritional and longitudinal studies focused specifically on understanding the drivers of obesity in SA, particularly in women.

Of particular concern is the increase in abdominal obesity in SA, especially in women, in whom the increase was independent of that of total adiposity. Abdominal obesity, characterised by WC or WHtR, is a key driver of cardiometabolic risk associated with obesity.[19,20] Commensurate with these findings, a study in middle-aged African women, using dual-energy X-ray absorptiometry to characterise changes in body composition over a 13-year follow-up, showed a redistribution of body fat from the periphery to the central regions with increasing fatness. Notably, there was a relative increase in visceral adiposity, which was associated with incident type 2 diabetes.[74] The increase in centralisation of body fat appears to be linked with high levels of adiposity, at which point the adipocyte size reaches capacity and fat is redirected to ectopic sites, including the visceral depot.[75-77] This points to the need to reduce the rising rates of obesity, particularly severe obesity, in women.

While differences across other sociodemographic indicators were less pronounced, they remained notable. Importantly, the factors that previously distinguished obesity prevalence – such as geographical type, province and population group – became less prominent in later surveys. This shift reflects a disproportionately rapid increase in obesity among groups and areas that initially exhibited lower prevalence. For example, among women, the rate of increase in abdominal obesity was higher in rural compared with urban areas, as evidenced by significant rises in central obesity in rural provinces such as Limpopo, Mpumalanga and Northern Cape. In men, increases in obesity prevalence were primarily observed in the same provinces, as well as among black African and coloured men, who had among the lowest prevalence rates in earlier surveys. Similarly, among women, obesity prevalence rose in groups with initially lower rates – namely white and Asian women – resulting in minimal differences between population groups by 2017. Collectively, these findings point to a widespread and systemic increase in obesity across SA.

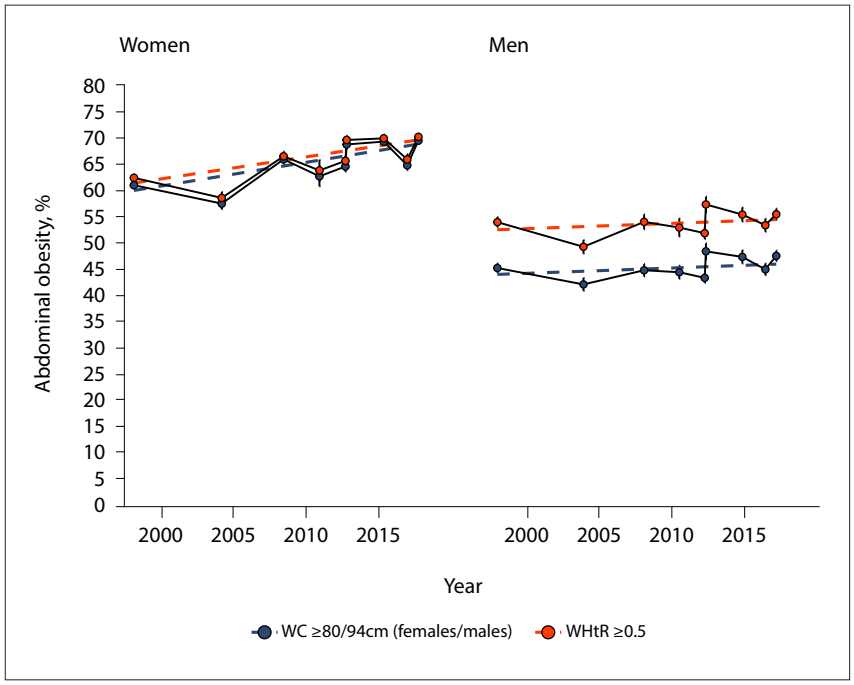

Fig. 4. Prevalence of waist circumference (WC)-defined and waist-to-height ratio (WHtR)-defined abdominal obesity in the South African adult population (aged ≥18 years) by sex between 1998 and 2017. Dashed lines are inverse-variance weighted linear trends.

Study strengths and limitations

Strengths of this study are the use of large representative samples of the SA adult population at different time points, and the use of direct (as opposed to self-reported) anthropometric measurements taken by trained staff with standardised methodologies. Other strengths include the harmonisation of the sociodemographic and geographical variables of interest, the recalibration of sampling weights to consistent population series to reduce inter-survey bias, and the simultaneous analysis and comparison of multiple indicators of adiposity.

Several limitations also need to be considered. First, the estimates are the result of a joint analysis of independently conducted surveys with considerable differences in designs and data collection methods, resulting in some inherent heterogeneity, also evident in the discrepancy between estimates from surveys conducted in similar periods. This heterogeneity could have introduced some bias in the trend estimates, especially within population strata. However, given

Table 2. Average rate of change in the prevalence of general and abdominal obesity in the South African adult population (aged ≥18 years) between 1998 and 2017

	Women, %/decade (95% CI)			Men, %/decade (95% CI)		
	General	Abdominal		General	Abdominal	
Characteristic	BMI ≥30 kg/m²	WC ≥80/94 cm	WHtR ≥0.5	BMI ≥30 kg/m²	WC ≥80/94 cm	WHtR ≥0.5
Age, years						
18 - 24	**3.8** (2.7 - 4.8)	**8.9** (2.1 - 15.7)	**9.2** (2.8 - 15.7)	0.3 (–0.9 - 1.4)	0.9 (–0.8 - 2.6)	1.6 (–2.6 - 5.7)
25 - 34	**7.6** (4.4 - 10.9)	**10.2** (3.2 - 17.2)	**9.7** (2.7 - 16.6)	0.5 (–1.2 - 2.2)	1.6 (–2.5 - 5.6)	2.1 (–3.3 - 7.6)
35 - 44	**6.9** (3 - 10.8)	7.3 (–0.6 - 15.1)	7.3 (–0.2 - 14.8)	–0.3 (–2.5 - 2)	–1.3 (–6 - 3.4)	–0.7 (–6.7 - 5.2)
45 - 54	**7.7** (4.6 - 10.7)	**6.8** (1.3 - 12.3)	**7** (1.4 - 12.6)	0.2 (–3 - 3.5)	1.7 (–6.5 - 9.9)	–1.2 (–8.6 - 6.2)
55 - 64	**7.8** (2.6 - 13.1)	**7.1** (0.2 - 14)	**6.3** (0 - 12.5)	**4.5** (1.7 - 7.2)	8.2 (–0.2 - 16.6)	3.7 (–3 - 10.4)
65 - 74	**10** (6.8 - 13.2)	**7.9** (2.9 - 12.9)	**7.6** (2.7 - 12.5)	**4.2** (0.8 - 7.6)	7 (–2.4 - 16.5)	6 (–1.3 - 13.2)
≥75	**7.1** (0.2 - 13.9)	**5.4** (0.5 - 10.3)	3.1 (–0.9 - 7)	3.6 (–6.8 - 13.9)	8.2 (1.8 - 14.6)	8.6 (–0.8 - 18.1)
Population group						
Black African	**6.9** (4.8 - 9.1)	**9.1** (3.1 - 15.2)	**8** (2.3 - 13.8)	**1.2** (0.1 - 2.4)	3.4 (–0.7 - 7.5)	3.7 (–1.8 - 9.2)
Coloured	**8.3** (4.7 - 12)	**9.4** (2.5 - 16.3)	**8.5** (1.8 - 15.3)	**3.6** (1.4 - 5.8)	**5.7** (0.4 - 11.1)	3.6 (–2.3 - 9.5)
White	**10.4** (5.9 - 14.9)	**11.7** (3.4 - 19.9)	**12.4** (5.9 - 18.9)	3.5 (–1.7 - 8.6)	0.8 (–9.3 - 11)	1 (–6.9 - 9)
Asian	**8.8** (5.1 - 12.6)	**18.4** (6.8 - 30)	**13.8** (4.1 - 23.5)	0.2 (–3.3 - 3.8)	4.4 (–18.7 - 27.6)	4.1 (–9.4 - 17.6)
Geographical type						
Rural	**9.2** (5.9 - 12.4)	**10.4** (3.5 - 17.3)	**9.9** (2.1 - 17.7)	1 (–0.2 - 2.2)	3.1 (–1.6 - 7.7)	4.1 (–1.9 - 10.2)
Urban	6.7 (4.6 - 8.9)	**8.8** (3.1 - 14.6)	**8.3** (3.5 - 13.2)	1.2 (–0.6 - 3.1)	1.9 (–3.5 - 7.3)	1.3 (–4.5 - 7.1)
Province						
WC	**10.3** (6.7 - 13.9)	**10.2** (1.8 - 18.5)	**10.2** (2.4 - 18.1)	1.7 (–1.4 - 4.8)	5 (–1.1 - 11.1)	0.6 (–5.1 - 6.4)
EC	**7.3** (5.3 - 9.3)	**9** (4.6 - 13.3)	**7.8** (3.8 - 11.8)	0.6 (–0.7 - 2)	1.4 (–2.4 - 5.2)	–0.3 (-5.2 - 4.6)
FS	**10.7** (8.5 - 12.9)	**13.7** (4.9 - 22.5)	**13.6** (5.4 - 21.7)	1.5 (–1.4 - 4.3)	2.3 (–4.4 - 9)	3 (–3.6 - 9.7)
GT	**5** (1.2 - 8.8)	**7.6** (2.2 - 13.1)	**7.5** (2.8 - 12.2)	0.4 (–1.7 - 2.5)	1.1 (–6.9 - 9.1)	1.1 (–5.8 - 8.1)
KZN	**7.1** (2 - 12.2)	6.6 (–0.6 - 13.8)	5.4 (–2.9 - 13.8)	0.2 (–1.6 - 2)	0.9 (–4.4 - 6.1)	0.2 (–6.6 - 6.9)
LI	**8.7** (5.3 - 12.1)	**14.3** (6.3 - 22.2)	**11.8** (3.7 - 20)	**1.7** (0.1 - 3.2)	4.5 (–0.5 - 9.4)	7.1 (–2 - 16.2)
MP	**5.2** (4.1 - 6.4)	**11.7** (2.2 - 21.2)	**10.9** (1.6 - 20.2)	**2.2** (0.2 - 4.2)	3.1 (–1.7 - 8)	5 (–3.5 - 13.4)
NC	**8.3** (4.5 - 12.1)	**11.9** (3.9 - 19.9)	**13** (4.7 - 21.2)	**3.1** (1.2 - 5)	4.9 (–1.4 - 11.2)	**7.2** (1 - 13.5)
NW	**12.8** (8.5 - 17.2)	**11.3** (2.6 - 20.1)	**12.1** (5.3 - 18.8)	**2.7** (0.9 - 4.5)	3 (–4.6 - 10.5)	6 (–3.3 - 15.3)

CI = confidence interval; BMI = body mass index; WC = waist circumference; WHtR = waist-to-height ratio; WC = Western Cape; EC = Eastern Cape; FS = Free State; GT = Gauteng; KZN = KwaZulu-Natal; LI = Limpopo; MP = Mpumalanga; NC = Northern Cape; NW = North West.
Statistically significant trends in bold.

the extensive harmonisation procedure applied to the raw data, we consider the presence of bias of a magnitude sufficient to invalidate the conclusions of this study implausible. Second, the NIDS surveys, unlike the other cross-sectional surveys, included a panel component of individuals who were interviewed in multiple waves as part of the nationally representative cross-sections. This introduced some form of dependence across samples, which was not considered in the analyses. Finally, the unavailability of raw data from the National Food and Nutrition Security Survey conducted in 2021[32] (the only national survey including direct anthropometric measurements conducted after 2017) did not allow for their inclusion in the trend estimates, thus limiting the timespan of our study to the period 1998 - 2017.

Conclusion

This study found evidence of a significant and widespread increase in general and abdominal obesity among SA women from 1998 to 2017. The prevalence of obesity has risen across all population segments, reducing historical disparities and disproportionately impacting groups that previously exhibited lower prevalence. The sharp increase in abdominal obesity raises significant alarm given its strong association with visceral fat accumulation, metabolic dysfunction and elevated risk of non-communicable diseases (NCDs). In contrast, obesity trends among men have remained relatively stable, with consistently lower prevalence and little evidence of significant change over time.

These trends are a major concern in the context of global and national commitments to combat NCDs. The World Health Organization's Global Monitoring Framework identifies obesity as a key risk factor for NCDs, and aims to halt its rise by 2030. SA's own National Strategic Plan for the Prevention and Control of Non-Communicable Diseases adopts this framework, with the goal of reducing premature mortality from NCDs by one-third by 2030, in line with Sustainable Development Goal 3.4. Without urgent and sustained public health action, the growing burden of obesity – particularly abdominal obesity – threatens to undermine progress towards these critical targets.

Our findings emphasise the need for increased research to better understand the complexity of the obesity epidemic and its drivers. This research is essential for informing evidence-based prevention efforts and policy strategies. We also call for improved routine and *ad hoc* data collection at the population level to effectively evaluate the impact of interventions, and track progress towards these important national and global objectives.

Data availability. Anonymised individual-level data from the five waves of the NIDS and the 1998 and 2016 SA DHS are publicly available through the DataFirst Open Data Portal at the University of Cape Town. Data from the SANHANES are publicly available through the Human Sciences Research Council Research Data Repository. Data from the 2003 SA DHS are available upon reasonable request from the SA National Department of Health, Chief Directorate: Research, Monitoring and Evaluation.

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