Body Mass Index in Middle Age and Health-Related Quality of Life in Older Age

The Chicago Heart Association Detection Project in Industry Study

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Background: Overweight and obesity are associated with higher morbidity and shorter life expectancy, but the effect of body mass index (BMI) (calculated as weight in kilograms divided by the square of height in meters) ascertained during middle age on subsequent quality of life among older survivors is unknown. This study evaluates whether BMI in middle age is related to health-related quality of life in older age.

Methods: This prospective cohort of adults from the Chicago Heart Association Detection Project in Industry included 6766 middle-aged men and women, aged 36 to 64 years, without diabetes mellitus or myocardial infarction at baseline (November 7, 1967–January 8, 1973), who completed a 26-year follow-up questionnaire in 1996 when they were 65 years and older. Relationships of baseline BMI (categories: normal weight, overweight, and obese) to mean 26-year follow-up Health Status Questionnaire 12 scores (measuring physical, mental, and social well-being) were assessed.

Results: For men and women, BMI had significant inverse-graded associations with all Health Status Questionnaire 12 scores ($P < .01$ for trend for all). Scores (adjusted for baseline cardiovascular disease risk factors and 1996 age) were highest (best) in normal-weight individuals (BMI, 18.5–25.0) and decreased significantly ($P$ range, .006–.001 for trend) with higher BMI, with worst outcomes for obese persons (BMI, $\geq 30.0$). A higher multivariate-adjusted percentage of normal-weight persons reported excellent or very good health compared with overweight and obese persons: for women, 46.8% vs 37.9% and 24.3%; and for men, 53.8% vs 49.1% and 36.5% ($P < .001$ for trend).

Conclusions: A higher BMI in middle age is associated with a poorer quality of life in older age. Preventive measures may lessen the burden of disease and impaired quality of life associated with excess weight.

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SINCE THE BEGINNING of the 20th century, there have been dramatic improvements in life expectancy, with a decline in mortality before the age of 65 years contributing substantially to these gains. An individual reaching the age of 65 years can expect to live on average an additional 18 years, and life expectancy should continue to increase. With the baby boomer generation poised to enter old age, it is estimated that by 2030, 20% of the US population will be 65 years or older, with the oldest old (persons $\geq 85$ years) comprising the fastest-growing segment. Some contend that increased life expectancy will lead to growing numbers of frail, disabled, and institutionalized older persons with a decreased quality of life and increased costs for health care. Alternatively, as recently demonstrated, older individuals with favorable levels of coronary heart disease risk factors during young adulthood or middle age have greater longevity and substantially lower health care costs, and they may also have better health-related quality of life (an individual’s physical, mental, and social well-being), a paramount issue among older people.

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While the prevalence of most major risk factors for coronary heart disease, such as adverse serum cholesterol and blood pressure levels and smoking, has declined in the United States, the prevalence of overweight and obesity among adults has increased markedly during the past few decades. Approximately 108 million adults in the United States are overweight or obese. The impact of excess weight on physical health is well documented; obesity is associated with higher morbidity risk and shorter life expectancy. In recent years, research...
interest has focused on predictors of quality of life. However, most data are from cross-sectional studies or have focused on physical functioning, and there are uncertainties regarding the association between excess weight and health-related quality of life. To our knowledge, the relation of body mass index (BMI) (calculated as weight in kilograms divided by the square of height in meters) earlier in life to future quality of life, particularly in older age, has not been examined. This report provides new population-based information on the relation of BMI measured in middle-aged employed men and women to subsequent health-related quality of life in older age, after an average follow-up of 26 years; data are from the Chicago Heart Association Detection Project in Industry (CHA) Study.

METHODS

PARTICIPANTS AND BASELINE EXAMINATION

Between November 7, 1967, and January 8, 1973, the CHA study screened 39522 women and men 18 years and older. All employees of 84 Chicago-area companies and organizations, about 75,000 people, were invited to participate; the volunteer rate was 53%. Details of the baseline examination have been reported. Brieﬂy, trained staff measured height, weight, a single casual supine blood pressure using a standard mercury sphygmomanometer, and serum total cholesterol level (nonfasting serum sample analyzed by an automated adaptation of the method of Levine and Zak). All measurements were collected in a standardized way, using a single protocol with uniform methods at all screening sites. A self-administered questionnaire was used to collect demographic data, smoking history, and information on medical diagnoses and treatment of hypercholesterolemia, hypertension, diabetes mellitus, and myocardial infarction. Resting electrocardiograms were classiﬁed as having major, minor only, or no abnormalities based on the criteria of the Hypertension Detection and Follow-up Program.

FOLLOW-UP QUESTIONNAIRE

In 1996, a health survey was mailed to all surviving CHA participants 65 years and older with available addresses (n=12,409). Current addresses for 92.2% of these participants were obtained from the Health Care Financing Administration (recently renamed the Centers for Medicare & Medicaid Services) by matching records with name, sex, date of birth, and social security number. For the remaining participants, addresses provided at the baseline examination were used. Institutional review board approval to contact participants by mail 26 years after the baseline examination was received. The 4-page questionnaire included self-reports of risk factors, health-related quality of life, habitual exercise pattern, alcohol consumption, smoking history, history of diseases and conditions (eg, cancer by site, hypertension, diabetes mellitus, and myocardial infarction), current medication use for hypertension, hypercholesterolemia, diabetes mellitus, and myocardial infarction (for women). The response rate was 59.8%; the average follow-up was 25.8 years for all respondents.

EXCLUSIONS

Of the 7417 participants (3291 women and 4126 men) 65 years and older in 1996 who completed the questionnaire, 651 were excluded for the following reasons: baseline age of 65 years or older (n=36); history of myocardial infarction (n=60) or diagnosis of diabetes mellitus (n=142) at baseline; missing data on baseline diabetes mellitus (n=21), height or weight (n=4), blood pressure (n=3), serum cholesterol level (n=29), smoking status (n=3), or educational level (n=8); and missing Health Status Questionnaire 12 (HSQ-12) measures at follow-up (n=285). In addition, 38 participants (53 women and 5 men) who were underweight at baseline (BMI, <18.5) were excluded from the cohort because of small numbers in the category. Thus, this report is based on 2936 women and 3830 men 65 years and older in 1996 with complete data on baseline risk factors and follow-up measures of quality of life.

BASELINE BMI AND FOLLOW-UP QUALITY-OF-LIFE MEASURES

By using the BMI categories adopted by the National Institutes of Health and the World Health Organization, participants were grouped according to baseline BMI levels as normal weight (BMI, 18.5–<25.0), overweight (BMI, 25.0–<30.0), and obese (BMI, ≥30.0). Primary analyses were based on these 3 BMI categories. Furthermore, obese participants were subdivided into 2 groups: obesity class 1 (BMI, 30.0–<35.0) and obesity classes 2/3 (severely obese) (BMI, ≥35.0). Additional analyses were conducted using 4 BMI groups (including the normal and overweight categories). The self-reported HSQ-12, developed by the Health Outcomes Institute, was used to measure quality of life. The validity and reliability of the HSQ-12 in measuring quality of life in older individuals have been demonstrated. Similar to the Medical Outcomes Trust 12-Item Short-Form Health Survey, the HSQ-12 was designed to provide measures of physical functioning (ability to perform daily tasks and activities), mental health (subjective evaluation of one’s own physical and emotional well-being), and social functioning (degree to which physical or emotional problems interfere with individual social activities). The HSQ-12 captures 8 domains: (1) health perception, (2) physical functioning, (3) role limitations due to physical health, (4) bodily pain, (5) energy/fatigue, (6) social functioning, (7) role limitations due to emotional problems, and (8) mental health. For each domain, categorical responses are scaled into numeric scores, ranging from 0 to 100, according to the HSQ-12 scoring protocol—the higher the score, the better the outcome. Categorical responses to each HSQ-12 item were also dichotomized to indicate favorable outcomes (eg, excellent or very good self-rated health vs all others) or adverse outcomes (eg, fair or poor health vs all others). These binary outcomes provide a more intuitive interpretation of each HSQ-12 item, expressed as percentage of people with favorable or unfavorable outcomes.

STATISTICAL ANALYSIS

All analyses by baseline BMI groups were performed separately for women and men. χ² (for categorical variables) or F (for continuous variables) tests were used to detect statistically significant differences in baseline characteristics across the groups. General linear models were used to compute group mean domain scores, adjusted for age (in 1996), race (African American or not), and variables assessed at baseline (educational level [in years], cigarette smoking [number per day], and minor and major electrocardiographic abnormalities [yes or no]). The BMI groups were entered in the linear models as a class variable. Adjusting for the same set of variables, we computed the prevalence (percentage) of favorable (good) outcomes and adverse (bad) outcomes for the 12 HSQ-12 items comprising the 8 domains by BMI category using general linear models. These values were covariate-adjusted least-squares estimates. In addition to age, race, baseline educational level, cigarette smoking, and electrocardiographic abnormalities, HSQ-12 mean scores were adjusted for baseline systolic blood
but not significantly (P=.18), among men with excess weight compared with normal-weight men.

HSQ-12 SCORES

Unadjusted means, SDs, medians, and interquartile ranges of HSQ-12 domain scores by sex are shown in Table 2.

Table 1 presents the baseline characteristics of study participants by BMI group for men and women separately. Women with a normal weight compared with those who were overweight and obese were on average slightly younger, had lower average systolic and diastolic blood pressures, and had a lower average serum cholesterol level. Other baseline characteristics were also more favorable for normal-weight women (eg, higher educational levels and a lower prevalence of electrocardiographic abnormalities). However, the proportion of smokers was higher among women with a normal weight: more than 30% were smokers, smoking on average 18 cigarettes per day. Similar results for baseline characteristics were observed among men (Table 1), except that number of cigarettes smoked per day was higher, but not significantly (P=.18), among men with excess weight compared with normal-weight men.

Table 1. Baseline Characteristics of 2936 Women and 3830 Men 65 Years and Older in 1996 According to Categories of BMI at Baseline in 1967 to 1973*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18.5–&lt;25.0</td>
<td>25.0–&lt;30.0</td>
</tr>
<tr>
<td></td>
<td>(n = 1831)</td>
<td>(n = 824)</td>
</tr>
<tr>
<td></td>
<td>18.5–&lt;25.0</td>
<td>25.0–&lt;30.0</td>
</tr>
<tr>
<td></td>
<td>(n = 1086)</td>
<td>(n = 2171)</td>
</tr>
<tr>
<td>BMI</td>
<td>22.3 (1.6)</td>
<td>27.0 (1.4)</td>
</tr>
<tr>
<td>Age, y</td>
<td>48.0 (5.9)</td>
<td>49.5 (6.0)</td>
</tr>
<tr>
<td>African American race‡</td>
<td>3.6</td>
<td>4.4</td>
</tr>
<tr>
<td>Blood pressure, mm Hg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systolic</td>
<td>129.6 (17.1)</td>
<td>136.1 (18.1)</td>
</tr>
<tr>
<td>Diastolic</td>
<td>76.8 (10.2)</td>
<td>80.1 (10.7)</td>
</tr>
<tr>
<td>Serum cholesterol level, mg/dL</td>
<td>211.7 (38.5)</td>
<td>216.9 (38.5)</td>
</tr>
<tr>
<td>Current smoker‡</td>
<td>30.7</td>
<td>21.6</td>
</tr>
<tr>
<td>No. of cigarettes/d for smokers</td>
<td>18.0 (8.9)</td>
<td>16.8 (9.4)</td>
</tr>
<tr>
<td>ECG abnormality§</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minor only</td>
<td>3.8</td>
<td>4.5</td>
</tr>
<tr>
<td>Major</td>
<td>9.3</td>
<td>9.5</td>
</tr>
<tr>
<td>Educational level, y</td>
<td>12.7 (2.1)</td>
<td>12.1 (2.2)</td>
</tr>
</tbody>
</table>

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by the square of height in meters); normal weight, BMI 18.5–<25.0; overweight, BMI 25.0–<30.0; and obese, BMI ≥30.0; ECG, electrocardiographic.

§Conversion factor: To convert cholesterol to millimoles per liter, multiply by 0.0259.

*Data are given as mean (SD) unless otherwise indicated.

†P<.001 for overall group differences, from χ² tests (for categorical variables) or F tests (for continuous variables).

‡Data are given as percentage of each group.

‡P<.05 for overall group differences, from χ² tests (for categorical variables) or F tests (for continuous variables).

Results

Multivariate-adjusted mean HSQ-12 domain scores by BMI group and sex are shown in Table 3. There was an inverse-graded association between BMI and all 8 scores for men and women. For example, women with a normal weight had an adjusted health perception score of 63.7, which is 7.0 and 15.5 points higher than overweight and obese women, respectively. In general, the inverse associations were stronger for physical health (physical functioning, physical role limitations, and bodily pain) than for mental health or social well-being. Tests for linear trend showed that all trends were statistically significant (P range, .006 to <.001). Adjustment for obesity-related major risk factors, serum cholesterol level, and blood pressure lowered HSQ-12 mean scores only slightly (data not shown); tests for linear trend remained highly significant (P<.001) for both sexes.

For the 12 individual quality-of-life items, the prevalence of good outcomes was highest for normal-weight groups and decreased with higher BMIs. On the other hand, for all items, the prevalence of bad outcomes was lower for men and women with a BMI lower than 25.0, and increased with higher BMIs (P range, .01–<.001, for trend; results not shown). Figure 1 (women) and Figure 2 (men) are examples of specific items of health perception (individual perception of one’s health [A] and physical functioning [B, C, and D]), multivariate adjusted and categorized by BMI. A higher proportion of men and women with a BMI lower than 25.0 reported excellent or very good health compared with those who were overweight and obese (for women, 46.8% vs 37.9% and 24.3%, respectively; and for men, 53.8% vs 49.1% and 36.5%, respectively) (P<.001 for trend). Conversely, proportions of men and women who reported fair or poor health were lower among normal-weight persons compared with those who were over-
weight and obese (for women, 16.3% vs 23.5% and 30.5%, respectively; and for men, 13.3% vs 14.8% and 19.2%, respectively) (P < .001 for trend). Three items deal with physical functioning (performance of physical activities): lifting or carrying groceries, climbing stairs, and walking several blocks. The percentages of good outcomes (ie, having no limitations) and bad outcomes (ie, having extensive limitations) are presented. For all 3 items, there was a consistently higher prevalence of good outcomes and a lower prevalence of bad outcomes associated with a lower BMI (P range, < .01 to < .001 for trend, most at P < .001).

Additional analyses using 4 baseline BMI strata (normal weight, overweight, obese, and severely obese) showed a graded and inverse relationship between BMI and quality of life, with the severely obese men and women (BMI, ≥35.0) having the lowest health domain scores (ie, worst quality of life). The prevalence of favorable outcomes, particularly for health perception and physical-related items, was much lower and the prevalence of adverse outcomes was much higher for severely obese women and men than for obese individuals (BMI, 30.0-<35.0), who, in turn, have a lower quality of life compared with those of normal weight (BMI, 18.5-<25.0) or even those who are overweight (BMI, 25.0-<30.0). For example, for women, the multivariable-adjusted prevalence of having no limitation in walking several blocks...
was 59.5%, 48.9%, 35.3%, and 18.5% for normal-weight, overweight, obese, and severely obese subjects, respectively (P<.001 for trend). Corresponding numbers for men were 74.0%, 68.8%, 53.8%, and 40.7% (P<.001 for trend).

The population segment 65 years and older in the United States (12.4%) is estimated to grow to 20% by 2030.\textsuperscript{2,3,41-43} This trend in aging is a global phenomenon, with the numbers of people 60 years or older worldwide expected to increase from 1 in 10 currently to 1 in 5 by 2050, and developing nations expected to face the greatest rate of population aging.\textsuperscript{42,43} With more people surviving to older ages, it is becoming increasingly important to address not only morbidity but also the disability and poor quality of life that can accompany aging even in the absence of clinical disease. The ideal outcome of increased years of survival is to enjoy those years disability free and healthy. This concept is described by the compression-of-morbidity hypothesis, which proposes that while life span has its limits, age of onset of morbidity can be postponed, reducing number of years of disability and disease to a brief period before death.\textsuperscript{44} While this has not been conclusively proved, it has been reported that individuals with favorable health risk (determined by smoking status, BMI, and exercise patterns) have half the cumulative disability of those at high risk after 32 years of follow-up, and onset of disability was postponed by approximately 5 years in the low-risk compared with the high-risk group.\textsuperscript{45} These findings suggest that healthy habits and traits may lead to postponement of initial disability and decreased lifetime disability.

Our main finding, based on an average follow-up of 26 years, is that BMI level in middle-aged men and women is significantly and independently related to various aspects of self-reported quality of life (physical, social, and mental well-being) in older age. Among normal-weight individuals, preservation of health status was evident in the physical, emotional, and social domains. Scores for all health status scales, measuring physical and social functioning and mental health, were highest (best) in men and women with a normal weight at baseline, and decreased significantly with higher BMI, with worst outcomes among severely obese individuals. An examination of specific items also shows that a higher proportion of men and women who were normal weight have no limitation in common basic physical activities and perception of men and women who were normal weight have no limitation in common basic physical activities and perceive themselves as having excellent or very good health.

Self-perception of health is important because poor subjective health has been shown to relate to mortality risk, independent of physical health.\textsuperscript{46-48} Much attention has been focused on the prevention of chronic diseases by prevention and control of ma-
major risk factors, with a resultant reduction in mortality and an increase in longevity. However, chronic disease risk factors, which can be largely asymptomatic, can also cause subclinical disease and affect quality of life. Overweight (BMI, 25.0–<30.0) and obesity (BMI, ≥30.0) are important determinants of type 2 diabetes mellitus, insulin resistance, hypertension, and dyslipidemia, and are independently associated with future morbidity and mortality from coronary heart disease and cardiovascular disease. In addition, excess weight is strongly related to higher risk of some types of cancers (endometrial, prostate, colon, and breast), gallbladder disease, osteoarthritis, sleep apnea, respiratory problems, and other conditions. Based on the results of our postal survey, which included a checklist of 22 major diseases or conditions, normal-weight individuals had significantly lower self-reported age-adjusted prevalence of any illness compared with those who were overweight and obese (48.2% vs 54.8% and 65.3%, respectively; P < .001 for trend). Furthermore, high BMI levels have been associated with increased health care costs. Unlike most other coronary risk factors, the prevalences of overweight and obesity are increasing. Recent data from the National Health and Nutrition Examination Survey 1999 to 2000 show that the age-adjusted prevalences of overweight and obesity among US adults are 34% and 31%, respectively, up from 33% and 23%, respectively, in 1994. Most previous studies on effect of BMI on quality of life are cross-sectional. They have generally demonstrated a negative impact of overweight and obesity on some aspects of quality of life. In a cross-sectional study of 4041 Dutch men and women aged 20 to 59 years, obesity was associated with an increased risk of impaired physical functioning. Obese men and women were twice as likely to have difficulties in performing a range of basic daily activities. However, adverse effects of overweight were apparent only among women. A cross-sectional postal survey in England of 8889 randomly selected adults, aged 18 to 64 years in 1997, included the Medical Outcomes Trust 36-Item Short-Form Health Survey. Persons with moderate to morbid obesity (BMI, ≥30) had significantly lower physical well-being scores than those in all other BMI categories. In the emotional well-being component, however, the overweight and obese persons did not score lower. In another relatively small cross-sectional study (of 51 men and 80 women from southwestern Ohio) of a broad age range (20-86 years), high levels of all major cardiovascular risk factors, including obesity, were associated with lower quality of life. Coefficients for the relation of obesity (BMI, ≥30.0) to Medical Outcomes Trust 36-Item Short-Form Health Survey scores were negative for 3 of 8 dimensions (physical functioning, general health, and vitality), but associations were not all significant. Because BMI was examined using only a single cut point of 30.0, the effect of other BMI levels is unknown.

The cross-sectional design of previous studies and the broad age range of samples preclude any inference as to the causal effect of BMI on health-related quality of life in older population strata. A possible explanation for the observed lack of associations of BMI with emotional health or social well-being in these studies may be the inclusion of younger persons, for whom sufficient time had not elapsed for the adverse effects of high BMI levels to become apparent. On the other hand, our findings, with an average follow-up of 26 years, demonstrate that high BMI levels do have significant adverse effects, not only on physical health but also on emotional and social health, although to a lesser degree. Thus, overweight and obesity in middle age seem to impair numerous components of quality of life in older age.

The few longitudinal studies on quality of life in older age have mainly focused on the effect of BMI on physical disability and performance of activities of daily living, and not on the entire spectrum of quality of life, involving physical, mental, and social aspects of life. Ferraro et al used data from National Health and Nutrition Examination Survey I to assess the relation between BMI and disability (using disability indexes composed of only physical tasks) in 6833 persons aged 25 to 74 years at baseline, with 20 years of follow-up. They reported a higher risk of disability for obese people, but no consistent relationship of overweight to higher disability. In the Cardiovascular Health Study of 4800 older US men and women, higher self-reported weight at the age of 50 years (≥15 years before the initial examination) and higher current weight at older age (≥65 years) were associated with poorer outcomes, especially among women; heavier persons had poorer self-reported health (based on a question on health perception, 1 of 8 health domains), had more mobility difficulty, and took more medications. Our findings regarding health perception are remarkably similar to those of the Cardiovascular Health Study (ie, excess weight in middle age was related to poorer health status in older age). As in the Cardiovascular Health Study, results from our postal survey show that, compared with normal-weight participants, higher percentages of overweight and obese participants (44.6% vs 55.1% and 69.1%, respectively) were taking medications for blood pressure, cholesterol, or diabetes mellitus, which may also have influenced quality of life.

The limitations of our study include loss to follow-up for health assessment of a portion of eligible surviving original members of the CHA cohort, reflected in the response rate to the mailed survey (approximately 60%). The difficulties of long-term follow-up have been well documented, especially in studies in which participants have not been contacted for decades, and response rates have been similar to ours. As expected, in our cohort, compared with nonresponders of the follow-up survey, responders were younger, had more years of education, and were more likely to be men, to be white, and to have a better cardiovascular disease risk profile at baseline (ie, lower mean blood pressure and serum total cholesterol levels and lower prevalence of diabetes mellitus and smoking). In addition, the response rate among participants determined to be obese at baseline was lower compared with those who were overweight and normal weight (54.7% vs 60.6% and 60.5%, respectively). This finding suggests that the associations between BMI and quality of life reported herein are almost certainly underestimates, and that associations would have been stronger had we obtained a better response rate in the over-
weight and obese groups. A further limitation is that measurement of BMI was made at only a single point. Duration of overweight and obesity may well play an important role in lessening quality of life—a matter we could not assess. We also do not know how other factors related to obesity, such as physical inactivity or diet, may influence physical, mental, and social health. In addition, although participants with a history of myocardial infarction or a diagnosis of diabetes mellitus at baseline were excluded, it was not possible to exclude those who might have had cancer or other chronic diseases at initial examination, which might influence quality of life even decades later, because such information was not collected. Nevertheless, the likelihood is small that participants with cancer or other severe chronic diseases would still be alive 26 or more years later. Moreover, the CHA cohort was derived from employed persons in Chicago; thus, they were healthier than the general population.

In conclusion, the findings of our study demonstrate the adverse impact of high BMI in middle age on future health-related quality of life, including physical functioning, emotional health, and social functioning. With much of the US population middle-aged and older facing trends of increasing obesity and overweight, preventive measures are urgently required to lessen future individual and societal burden of disease, disability, cost of care, and impaired quality of life associated with excess weight. By middle age, lifestyle patterns and risk factors, including excess weight, have often been established for decades. Moreover, successful long-term treatment of obesity is known to be difficult.1,2 Thus, for those already overweight or obese, perhaps the only viable solution rests in the widespread deployment of innovative multifaceted media and community-based educational programs emphasizing the possibility of successful weight loss and weight maintenance through moderation of diet and increase in exercise. The decades-long national efforts against tobacco use that have resulted in a dramatic decrease in adult smoking behavior may serve as models.3 However, as a long-term goal, we cannot limit ourselves only to a strategy emphasizing weight reduction and treatment of obesity. Instead, strategies that emphasize primary prevention of excess weight from an early age, with the potential of ending the obesity epidemic and leading to improved quality of life, should also become an ongoing component of national public health policy.

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