Prevalence and risk factors for metabolic syndrome in Asian Indians: A community study from urban Eastern India

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ABSTRACT

Objectives: To determine the prevalence of metabolic syndrome and to identify predictors for the same, specific to an underdeveloped urban locale of Eastern India. **Materials and Methods:** *Study design:* Population-based cross-sectional study, with multistage random sampling technique. *Setting:* Urban city-dwellers in Orissa one of the poorest states of Eastern India bordering a prosperous state of Andhra Pradesh of Southern India. *Participants:* 1178 adults of age 20–80 years randomly selected from 37 electoral wards of the urban city. *Definition of Metabolic Syndrome:* We followed a unified definition of the metabolic syndrome by joint interim statement of five major scientific organizations – the International Diabetes Federation, the National Heart, Lung, and Blood Institute, the American Heart Association, the World Heart Federation, the International Atherosclerosis Society, and the International Association of the Study of Obesity. Individuals who meet at least three of five clinical criteria of abdominal obesity, hypertriglyceredimia, low HDL, hypertension, and hyperglycemia are diagnosed as having the condition; presence of none of these criteria is mandatory. Explicit cut points are defined for all criteria, except elevated waist circumference, which must rely on population and country-specific definitions. *Main Outcome Measure:* Prevalence and significant predictors of metabolic syndrome. *Statistical Analysis:* Both descriptive and multivariable logistic regression analyses. **Results:** Age-standardized prevalence rates of metabolic syndrome were 33.5% overall, 24.9 % in males and 42.3% in females. Older age, female gender, general obesity, inadequate fruit intake, hypercholesterolemia, and middle-to-high socioeconomic status significantly contributed to increased risk of metabolic syndrome. **Conclusion:** Metabolic syndrome is a significant public health problem even in one of the poorest states of India that needs to be tackled with proven strategies.

Key words: Asian Indians, coronary heart disease, cardiovascular disease, diabetes, obesity, metabolic syndrome, South Asians, urban population

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INTRODUCTION

Metabolic syndrome refers to a cluster of various interrelated cardiometabolic risk factors that promote the development of atherosclerotic cardiovascular disease (CVD) and Type 2 diabetes mellitus (T2DM).[1] It is now well known that metabolic syndrome is a risk factor for increased cardiovascular mortality and morbidity. Current definitions of metabolic syndrome differ and cardiovascular risk

appears to differ according to which component risk factors present. The prevalence of obesity and metabolic syndrome is rapidly increasing in India and other South Asian countries, leading to increased mortality and morbidity due to CVD and T2DM.[2,3] Approximately about one third of urban South Asians have evidence of the metabolic syndrome.[4] Moreover, insulin resistance was observed to be there in nearly 30% of Asian Indian children and adolescents and many exhibit features of metabolic syndrome.[5] Since metabolic syndrome and obesity track into adulthood, these clinical entities need to be recognized early in the life-course for effective prevention of T2DM and CVD.[6] A high prevalence of metabolic syndrome and associated cardiovascular risk factors have also been observed within rural to urban migrant population belonging to lower socioeconomic population groups residing in urban slums.[7,8] The main drivers are related to rapid nutritional changes, lifestyle and socioeconomic transitions, consequent to increasing affluence, urbanization, mechanization, and rural-to-urban migration.[8,9] Data also indicate that atherogenic dyslipidemia, glucose intolerance, thrombotic tendency, subclinical inflammation, and endothelial dysfunction are proportionately higher in Asian Indians than Caucasians. [2,10] Many of such manifestations are more severe and are seen at an early age in Asian Indians than Caucasians.[2,10] Metabolic syndrome and cardiovascular risk in Asian Indians/ South Asians are also heightened by their relative increase in body fat mass, truncal subcutaneous fat mass, intra-abdominal fat mass, and also in ectopic fat deposition. Cardiovascular risk cluster also manifests at a lower level of adiposity and abdominal obesity.[2,3]

Asian Indians have an increased prevalence of coronary heart disease (CHD) and T2DM amongst all ethnic groups. [2,11] This Asian Indian or South Asian Paradox refers to the fact that high prevalence of diabetes is seen in people originating from South Asian nations of Bangladesh, India, Nepal, Pakistan, and Sri Lanka, despite lower rates of obesity (as defined by conventional body-mass-index criteria).[2,3] South Asians also seem to have a peculiar body phenotype known as South Asian Phenotype, characterized by increased waist circumference, increased waist hip ratio, excessive body fat mass, increased plasma insulin levels and insulin resistance, as well as an atherogenic dyslipidemia, with low levels of HDL cholesterol and increased triglyceride levels.[2,3] All such factors predispose South Asians not only to T2DM but also to premature CHD. In addition, unique genetic markers could potentially make South Asians more susceptible to cardiometabolic risks.[2,10,12]

Unfortunately, representative periodic nationwide data on cardiovascular risk factors for monitoring and surveillance are lacking in India[13,14] let alone data from specific states within India. Earlier we reported that the state of Orissa, one of the poorest states of Eastern India bordering a prosperous state of Andhra Pradesh of Southern India, showed interesting variations in classical coronary risk factors within an urban population. Such a unique geographic location is an "open door" to cultural and socioeconomic interactions. Metabolic syndrome is a lifestyle disease and factors contributing to recent changing patterns in metabolic syndrome prevalence in this particular geographic region may provide interesting insights into tackling the ever-rising burden of T2DM and CVD within a wider context of South Asians. The present study has two important research questions: First, to update on changing patterns of metabolic syndrome in a unique urban Eastern Indian population; second, to quantify factors significantly contributing to such an underlying pattern.

MATERIALS AND METHODS

Sampling design and survey methods

This was a cross-sectional population survey and the study population was selected using a multistage random sampling technique. Details of study methodology have been published elsewhere.[15] In brief, the sampling frame constituted 37 electoral wards spread across the urban population of Berhampur city of Orissa state in Eastern India. A total of 1178 subjects who are 20 years of age finally participated in this study out of 1200 eligible subjects from an estimated population of 307,724 in 2001. Demographic, socioeconomic, and self-reported behavioral information (smoking, alcohol, physical activity, and diet), objective measures of anthropometry (height, weight, waist, and hip circumferences), biochemical (plasma glucose, total cholesterol, triglycerides, and HDL cholesterol levels), and electrocardiographic data were collected from all study participants. Detailed interviews were performed through a previously validated questionnaire based on the guidelines of World Health Organization.[16]

Metabolic syndrome definitions

Various diagnostic criteria have been proposed by numerous national/international organizations for

defining metabolic syndrome.[17-20] We have followed most recent definition from Joint Interim Statement[21] of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity and also a Consensus Statement for Diagnosis of Obesity, Abdominal Obesity and the Metabolic Syndrome for Asian Indians.[22] As per these consensus statements, three out of five cardiovascular risk factors have to be abnormal for the identification of the metabolic syndrome.[21,22]

Presence of any three of the following five conditions is essential, i.e.,

1. increased waist circumference (males: ≥90 cm and for females: ≥80 cm),
2. hypertriglyceredimia ≥150 mg/dl (1.7 mmol/l),
3. low HDL (Males <40 mg/dl (1 mmol/l) and for females <50 mg/dl (1.3 mmol/l),
4. elevated blood pressure (systolic blood pressure ≥130 mmHg and/or diastolic blood pressure ≥85 mmHg or drug treatment for hypertension), and
5. elevated blood sugar (fasting blood sugar ≥100 mg/ dl (5.6 mmol/l) or drug treatment for diabetes mellitus).[21,22]

Ethical approval

Institutional ethical committee approval was obtained prior to the start of study and informed consent was taken from all the study subjects.[23]

Statistical analysis

Significant differences in proportions of potential lifestyle factors by metabolic syndrome were estimated using Pearsons' chi-square. Univariate logistic regression and multivariable logistic regression analyses were performed using SAS software (9.1.2, NC, Cary, United States) to predict potential significant predictors of metabolic syndrome employing backward elimination modeling technique. We used the age-wise distribution of urban Orissa population used by National Health and Family Welfare Survey (NFHS) for both sexes and total population to compute expected metabolic syndrome patients across the whole population of Orissa applying the age-specific rates from our study population. On summing the expected metabolic syndrome patients for each age group for both sexes, the total was divided by the total NFHS population to compute the direct age-standardized rates for both sexes and total rates.

RESULTS

This was one of the large community-based surveys done from Eastern India for ascertaining the prevalence of cardiovascular risk factors with the aim of providing the baseline information on prevalence rates for intervention programmes to the policy planners.

Prevalence of metabolic syndrome

A very high prevalence rate of 43.2 % (n = 509) of metabolic syndrome was reported in this community. In this study, metabolic syndrome rates are significantly higher among females with 52.2% (n = 307) than in males at 34.2% (n = 202). Further age-standardized prevalence rates of metabolic syndrome were 33.5% overall, 24.9 % in males and 42.3% in females. The details of the same are depicted in Table 1 and Figure 1.

Demographic and clinical profile of subjects with and without metabolic syndrome

Our study reveals significant gender differences with higher prevalence of metabolic syndrome in females as compared to males (42.3% vs. 24.9%). Table 1 shows the gender-wise prevalence of metabolic syndrome across different age groups. The study also showed significantly higher rates of metabolic syndrome in older age groups. The metabolic syndrome rates do increase from 6.7% in age groups of 20–29 years peaking to 65.6% in age groups of 60–69 years.

Chi-square outputs of significant proportions within several clinical and demographic parameters available to the present study comparing subjects with and without metabolic syndrome are shown in Table 2. Proportionately more subjects with metabolic syndrome (43%) have sedentary lifestyle as compared to those without metabolic syndrome (27.1%). Likewise, proportionately more subjects with inadequate fruit intake (65% vs. 58.3%), general obese (67% vs. 26.2%), centrally obese (83.9% vs. 22.3%), hypertriglyceridemia (67.0% vs. 15.4%), and higher cholesterol levels (34.0% vs. 14.9%) have metabolic syndrome.

Prevalence of individual components of metabolic syndrome

All the individual components of metabolic syndrome

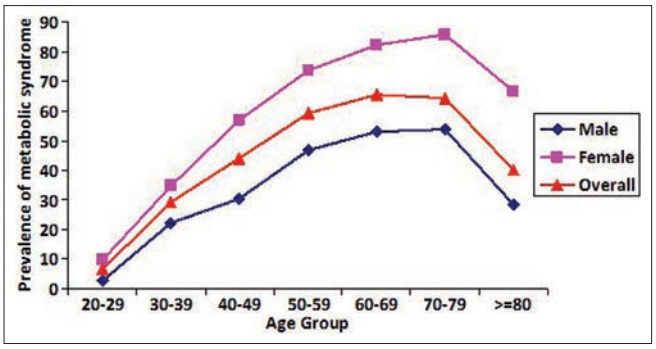

Figure 1: Age-specific prevalence of metabolic syndrome subjects in the study population

Table 1: Age-specific and age-standardized prevalence of metabolic syndrome subjects

Age (in years)	Total study subjects No			Metabolic syndrome subjects No (%)		
	Males	Females	Total	Males	Females	Total
20–29	68	81	149	2 (2.9)	8 (9.9)	10 (6.7)
30–39	108	145	253	24 (22.2)	50 (34.5)	74 (29.3)
40–49	145	153	298	44 (30.3)	87 (56.9)	131 (43.9)
50–59	137	118	255	64 (46.7)	87 (73.7)	151 (59.2)
60–69	87	67	154	46 (52.9)	55 (82.1)	101 (65.6)
70–79	38	21	59	20 (52.6)	18 (85.7)	38 (64.4)
80+	7	3	10	2 (28.6)	2 (66.7)	4 (40.0)
Total	590	588	1178	202 (24.9)	307 (42.3)	509 (33.5)

increased significantly with age. Overall in our study elevated blood pressure (63.1%) was the commonest abnormality observed and elevated blood sugar (31.2%) was the least common. Low HDL (84.5%) was the commonest abnormality among females, followed by elevated blood pressure (56.8%) and elevated blood sugar (28.9%) was the least common abnormality. Among males, elevated blood pressure (69.3%) was the commonest abnormality, followed by central obesity (41.9%). Low HDL (9.5 %) was the least common abnormality among males [Figure 2].

Significant predictors of metabolic syndrome

Detailed correlates of metabolic syndrome in univariate analysis for the base model are shown in Table 3. The final model of multivariate logistic regression method showing significant predictors of metabolic syndrome in this population are summarized in Table 4 Older age, female gender, general obesity, inadequate fruit intake, hypercholesterolemia, and being middle-to-higher socioeconomic status significantly contributed to an increased metabolic syndrome risk among this urban population. Those aged 45–64 years are more than four and half times and those above 65 years have five-fold increased risk of metabolic syndrome.

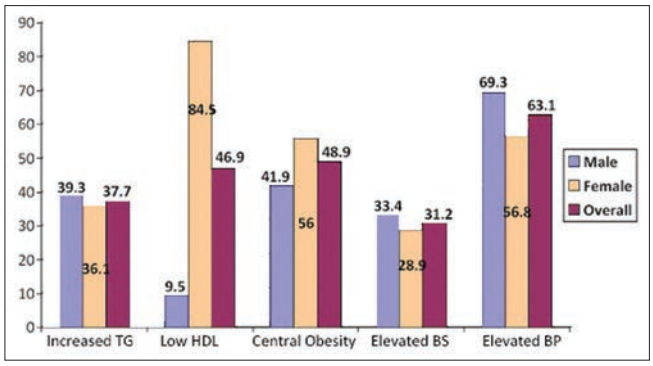

Figure 2: Individual components of metabolic syndrome in the study subjects. TG = Triglycerides; HDL = High-density lipoprotein; BS = Blood sugar; BP = Blood pressure.

Obese individuals were five times more likely to have metabolic syndrome compared with those having normal weight. Females were three times more likely to have metabolic syndrome compared to males. Likewise, individuals with hypercholesterolemia were almost two and half times as likely to be at risk of metabolic syndrome as those with normal levels. Similarly, there is increased metabolic risk among those who took inadequate fruit intake or middle-to-higher socioeconomic status [Table 4].

DISCUSSION

This cross-sectional study of adequate statistical power and representativeness (n = 1178) was conducted for the first time among an apparently urban healthy population in Eastern India, a region with unique lifestyles and culture. A very high metabolic syndrome prevalence rate of 33.5% was reported in this study population. Older age, female sex, general obesity, inadequate fruit intake, being middle-to-higher socioeconomic status, and hypercholesterolemia significantly contributed to an increased metabolic syndrome risk among this urban population.

The prevalence of metabolic syndrome is increasing exponentially in India, both in the urban and rural areas. It has escalated in different parts of India to figures now ranging from 11% to 41%.[24] The differences in the prevalence of metabolic syndrome between studies from Indian subcontinent may be attributed to different criteria employed, different age groups included, and different rates of prevalence of individual components of the metabolic syndrome. Comparison of our study with the one conducted at various cities across India illustrated this. Similarly, earlier studies across urban south India documented prevalence's

Table 2: Clinical/demographic characteristics of metabolic syndrome subjects

Variable	Subjects with MetS (*n* = 509)	Subjects without MetS (*n* = 669)	Total (%) *n* = 1178	*P* Value
Age years (mean ± SD)	51.66 ± 11.9	41.55 ± 13.8	45.92 (13.9)	0.000**
Sex				
Male	202 (39.7)	388 (58.0)	590 (50.1)	0.000**
Female	307 (60.3)	281 (42.0)	588 (49.9)	
Education				
Illiterate	60 (11.8)	73 (10.9)	133 (11.3)	0.461
Elementary	131 (25.7)	163 (24.4)	294 (25.0)	
High School	141 (27.7)	170 (25.4)	311 (26.4)	
College	177 (34.8)	263 (39.3)	440 (37.4)	
Socioeconomic status				
Lower	63 (12.4)	118 (17.6)	181 (15.4)	0.036*
Mddle	391 (76.8)	491 (73.4)	882 (74.9)	
Upper	55 (10.8)	60 (9.0)	115 (9.8)	
Smoking	117 (23.0)	203 (30.3)	320 (27.2)	0.005*
Physical Inactivity	219 (43.0)	181 (27.1)	400 (34.0)	0.000**
Low/no fruit intake	331 (65.0)	390 (58.3)	721 (61.2)	0.019*
Coronary heart disease	68 (13.4)	50 (7.5)	118 (10.0)	0.001*
Increased Blood pressure	454 (89.2)	289 (43.2)	743 (63.1)	0.000**
Increased Blood Sugar	302 (59.3)	65 (9.7)	367 (31.2)	0.000**
General Obesity BMI ≥25 kg/m^2	341 (67.0)	175 (26.2)	516 (43.8)	0.000**
Central Obesity (WC male ≥90 cm females ≥80 cm)	427 (83.9)	149 (22.3)	576 (48.9)	0.000**
Hypercholesterolemia ≥200 mg/dl	173 (34.0)	100 (14.9)	273 (23.2)	0.000**
Hypertriglyceridemia ≥150 mg/dl	341 (67.0)	103 (15.4)	444 (37.7)	0.000**
High LDL ≥130 mg/dl	129 (25.3)	136 (20.3)	265 (22.5)	0.041*
Low HDL (males <40 mg/dl, females <50 mg/dl)	331 (65.0)	222 (33.2)	553 (46.9)	0.000**

*Numbers in parenthesis indicate percentages. *P < 0.05. **P < 0.01. MetS = Metaboic syndrome; BMI = Body mass index; LDL = Low-density lipoprotein; HDL = High-density lipoprotein; WC = Waist circumference.*

ranging from 22.1% to 41%,[25-27] which is comparable with our observation of 33.5%. Likewise, a prevalence study of urban community in northern India reported a prevalence of 22.37% for metabolic syndrome.[28] On the contrary, a lower prevalence of 19.52% was reported in an urban population in western India.[29] While these studies show high prevalence of metabolic syndrome in Asian Indians living in India, truly representative data from all regions of India are not available.[2,4] Furthermore, there is paucity of data from other South Asian countries of Bangladesh, Nepal, Pakistan, and Sri Lanka.[2,4]

Women (52.2 %; n = 307) had significantly higher rates of metabolic syndrome compared to men (34.2 %; n = 202) in our study. In NHANES III data, the prevalence differed little among men (24.0%) and women (23.4%). [30] However, in many of the studies worldwide and in Indian subcontinent, women had a higher prevalence of metabolic syndrome.[31-34] More stringent cutoffs employed in women for waist circumference and HDL partly explain this variation. Also metabolic changes accompanying menopause might explain the increased prevalence of metabolic syndrome in women. In spite of higher prevalence of metabolic syndrome in women, it is widely recognized that male gender is significantly associated with cardiovascular risk.[35,36] Factors protecting women against cardiovascular risk are not clear, but to some extent may be explained by protective effect of endogenous estrogens against atherosclerosis in premenopausal females.[37]

Furthermore, Asian Indians are metabolically obese but physically nonobese.[38,39] In our study even with modified BMI cut-off values for South Asians/Asians, 33% of subjects did not have general obesity, but still had metabolic syndrome. For any given level of BMI, Asian Indians had been recognized to have increased prevalence of cardiometabolic abnormalities as compared to other ethnic groups.[40,41] Further physical activity levels are decreasing in Asian Indians[42] and present study reveals 43% of the subjects with metabolic syndrome are physically inactive.

Table 3: Correlates of metabolic syndrome: Univariate analysis

	n (%)	Met syndrome odds ratio (95%CI)	*P*
Gender			
Female (n = 588)	307 (52.2)	2.09 (1.65 – 2.65)	0.000**
Male (n = 590)	202 (34.2)	Reference	
General obese			
Yes (n = 516)	341 (66.1)	5.73 (4.45 – 7.37)	0.000**
No (n = 662)	168 (25.4)	Reference	
Physical activity			
No (n = 400)	219 (54.8)	2.03 (1.59 – 2.60)	0.000**
Yes (n = 778)	290 (57.0)	Reference	
Smoking			
Yes (n = 320)	117 (36.6)	0.68 (0.52 – 0.89)	0.004
No (n = 858)	392 (45.7)	Reference	
Fruit intake			
No (n = 721)	331 (45.9)	1.33 (1.04 – 1.68)	0.011*
Yes (n = 457)	178 (38.9)	Reference	
Socioeconomic status			
Lower (n = 181)	63 (34.8)	Reference	
Middle (n = 882)	391 (44.3)	1.49 (1.06 – 2.08)	0.021*
High (n = 115)	55 (47.8)	1.71 (1.06 – 2.76)	0.029*
Age			
<45 years(n = 560)	139 (24.8)	Reference	
45–64 yrs (n = 481)	288 (59.9)	4.52 (3.47 – 5.90)	0.000
>64 years(n = 137)	82 (59.9)	4.51 (3.05 – 6.68)	0.000
Hypercholesterolemia			
Yes (n = 273)	173 (63.4)	2.93 (2.21 – 3.87)	0.000*
No (n = 905)	336 (37.1)	Reference	
High LDL			
Yes (n = 265)	129 (48.7)	1.33 (1.01 – 1.75)	0.077
No (n = 913)	380 (41.6)	Reference	

*Numbers in parenthesis indicate percentages. *P < 0.05. **P < 0.01. MetS = Metaboic syndrome; BMI = Body mass index; LDL = Low-density lipoprotein; HDL = High-density lipoprotein; WC = Waist circumference.*

Table 4: Correlates of metabolic syndrome: final model (backward elimination logistic regression modeling)

Variables	Adjusted odds ratios (OR)	95% (CI) *P* value confidence intervals
Low/no fruit intake	1.608	1.17–2.20 0.003
General obesity	5.058	3.78–6.75 0.000
Age: 45–64 years	4.666	3.42–6.34 0.000
Age: ≥65 years	5.058	3.78–6.75 0.000
Hypercholesterolemia	2.434	1.73–3.41 0.000
Gender – Female	3.104	2.29–4.19 0.000
Socioeconomic status – Middle	1.573	1.02–2.41 0.038
Socioeconomic status – High	1.946	1.03–3.66 0.039

Low HDL is very common among Asian Indians and is corroborated also by various studies across South Asia. [4,33,43] The high prevalence of low HDL amongst women in our study can be attributed to a higher prevalence of central obesity as compared to men, a significant number of females of postmenopausal age in the study and in part due to more stringent cut off criteria for women adopted in the criteria.

We also found that the prevalence of metabolic syndrome increased with age in both sexes. It is noteworthy, that 7% of subjects in the age group of 20%–29% years had metabolic syndrome. The higher prevalence of metabolic syndrome in younger age in Asian Indians is of particular concern, as it implies that they will have a more prolonged exposure to atherosclerotic risk factors associated with metabolic syndrome.

In our study, metabolic syndrome was significantly more prevalent in among upper socioeconomic classes compared to lower socioeconomic strata. Accordingly, socioeconomic status has emerged as an independent risk predictor for metabolic syndrome in logistic regression analysis. Similar observations were noted in persons belonging to middle income groups had significantly higher prevalence of metabolic syndrome from a study in urban south India.[44]

In this context, our study presents the most recent prevalence rates for metabolic syndrome in an urban population aged 20–80 years from Eastern India. This study estimated very high prevalence of metabolic syndrome amongst the urban population in Eastern India. All the known classical cardiovascular risk factors were also found to be significant predictors of metabolic syndrome in the present study. However, published reports suggest that predictive risk factors are associated with risk of metabolic syndrome in different combinations in different populations across the country.

Strengths of the present study include a large population-based sample, representative sampling methodology, and the use of standardized data collection protocols. The use of population-based sample would provide greater support for generalizability. The survey had a very high response rate (98.16%).

Our study limitations are probability of a recall bias of the self-reported measures for behavioral risk factors, and possible biases from incomplete data

due to nonrespondents and missing item response data. Further, the study is an observational study, and therefore, no causal inferences can be made. Longitudinal follow-up studies are important to identify unmeasured/unknown and known risk factors and mediators on the causal pathway of cardiometabolic risk in this ethnically diverse population for a comprehensive control and prevention of CVD and T2DM among a wider Asian Indian community sharing similar lifestyle and culture.

In conclusion, a high prevalence of metabolic syndrome in this urban populace of Eastern India reinforces the need for a comprehensive noncommunicable disease prevention and control program. This is the first study conducted in one of the poorest states amidst socioeconomic transition mainly attributed to large scale industrialization and urbanizations. Cardiometabolic risk is high in Asian Indians/South Asians, starting at an early age. Increasing awareness of cluster of risk factors and how to prevent them comprehensively should be emphasized in population-wide prevention strategies in Asian Indians, in particular, and South Asians, in general.

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