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METABOLIC COMORBIDITIES IN HOSPITALIZED ADULTS: A STUDY OF DIABETES, DYSLIPIDEMIA, OBESITY AND CHRONIC ORGAN DISEASE.

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Background: The coexistence of multiple metabolic conditions including type 2 diabetes mellitus (T2DM), dyslipidemia, obesity, and hypertension is increasingly prevalent among hospitalized adults and is associated with significant end-organ damage. This study aimed to assess the socio-demographic profile, prevalence of metabolic comorbidities, biochemical parameters, and their association with chronic organ disease in hospitalized adults at a tertiary care center.
Methods:A hospital-based, cross-sectional observational study was conducted over 12 months (January–December 2021) in the Department of Medicine at a tertiary care teaching hospital. A total of 120 adult patients (age ≥ 18 years) with at least one confirmed metabolic comorbidity were enrolled using consecutive sampling. Socio-demographic data, anthropometric measurements, and biochemical investigations including HbA1c, fasting lipid profile, serum creatinine, and blood pressure were recorded using a structured proforma. Diagnostic criteria from ADA 2021, JNC 8, NCEP-ATP III, and harmonized IDF/AHA/NHLBI guidelines were applied.
Results: The majority of patients were in the 41–60 years age group (45.0%), male (56.7%), urban residents (61.7%), and of middle socio-economic status (51.7%). Hypertension was the most prevalent metabolic comorbidity (75.0%), followed by T2DM (68.3%), dyslipidemia (63.3%), and metabolic syndrome (48.3%). Over two-thirds of patients had excess body weight (obesity 36.7%; overweight 31.7%). All mean biochemical parameters — BMI (28.4 ± 4.2 kg/m²), HbA1c (7.8 ± 1.4%), total cholesterol (215 ± 35 mg/dL), triglycerides (185 ± 50 mg/dL), serum creatinine (1.4 ± 0.6 mg/dL), and systolic BP (142 ± 18 mmHg) — exceeded normal reference ranges. NAFLD was the most prevalent chronic organ complication (35.0%), followed by CKD (26.7%) and CAD (23.3%). A statistically significant stepwise increase in chronic organ disease was observed with increasing number of metabolic conditions: 18.2% with one condition, 39.1% with two, and 69.2% with three or more conditions ($p < 0.05$).
Conclusion: A high prevalence of metabolic comorbidities and their significant cumulative association with chronic organ disease was observed among hospitalized adults. The dose-dependent relationship between metabolic burden and end-organ involvement highlights the urgent need for integrated, multidisciplinary management strategies targeting all coexisting metabolic risk factors simultaneously to prevent progressive organ damage.

Keywords: Metabolic syndrome, Type 2 diabetes mellitus, Dyslipidemia, Hypertension, Obesity.

Introduction

Non-communicable diseases (NCDs) dominated by metabolic disorders have emerged as the foremost public health challenge of the 21st century. Among hospitalized adults, the coexistence of multiple metabolic conditions - including type 2 diabetes mellitus (T2DM), dyslipidemia, obesity, and hypertension - is increasingly common and collectively contributes to significant morbidity and end-organ damage. Understanding this metabolic burden and its cumulative impact on organ health is critical for designing effective preventive and therapeutic strategies.**[1]** Type 2 diabetes mellitus represents one of the most prevalent chronic diseases globally. The global diabetes prevalence in 2019 was estimated at 9.3%, affecting approximately 463 million people, with projections indicating a rise to 700 million by 2045.**[2]** India bears a disproportionately large share of this burden, with rising rates attributed to rapid urbanization, sedentary lifestyles, and dietary transitions.[3] Diabetic end-organ complications, including nephropathy, retinopathy, and accelerated cardiovascular disease, place an immense strain on healthcare systems, particularly in low- and middle-income settings. [4] Dyslipidemia, characterized by elevated total cholesterol, raised triglycerides, elevated LDL cholesterol, and low HDL cholesterol, is one of the most important modifiable risk factors for coronary artery disease (CAD). Studies in India have reported a high overall prevalence of dyslipidemia, with low HDL cholesterol being the most common abnormality, present in approximately 72.3% of subjects studied in representative population samples. Dyslipidemia frequently coexists with diabetes and obesity, amplifying the risk of atherosclerotic vascular disease and metabolic organ damage.[5,6] Obesity, defined as a body mass index (BMI) $\geq$ 30 kg/m^2, and overweight (BMI 25–29.9 kg/m^2), have become epidemic in both urban and rural populations. In Asian Indians, metabolic cardiovascular risk factors worsen continuously across the BMI spectrum, with each unit increase in BMI associated with exponential increments in the odds of developing hypertension, diabetes, and metabolic syndrome.[7] Non-alcoholic fatty liver disease (NAFLD), a hepatic manifestation of the metabolic syndrome, is closely associated with obesity, insulin resistance, and dyslipidemia, and has emerged as the most common chronic liver disease worldwide.[8] Metabolic syndrome -a cluster of central obesity, hypertension, insulin resistance, and atherogenic dyslipidemia - confers at least a twofold increased risk of cardiovascular disease and a fivefold increase in the risk of type 2 diabetes.[4] In the Indian context, metabolic syndrome prevalence is rising, driven by urban residence, physical inactivity, and higher socioeconomic strata.[9] When multiple metabolic conditions co-occur, the risk to target organs such as the kidney, heart, liver, and brain increases in a cumulative, dose-dependent manner. [10]
Despite this well-recognized burden, data on the simultaneous prevalence of multiple metabolic comorbidities and their combined association with chronic organ disease among hospitalized adults in India remain limited. This study was undertaken to assess the socio-demographic profile, prevalence of metabolic comorbidities, biochemical parameters, and their association with chronic organ disease in hospitalized adult patients, with the aim of providing evidence to guide integrated clinical management strategies.

Methods

Study Design and Setting

This was a hospital-based, cross-sectional observational study conducted in the Department of Medicine at a tertiary care teaching hospital. The study was carried out over a period of 12 months (January 2021 to December 2021). The institution serves both urban and rural populations across a wide catchment area, providing an adequate representation of diverse socio-demographic strata.

Study Population

All adult patients aged 18 years and above, admitted to the medical wards during the study period and diagnosed with one or more metabolic conditions (type 2 diabetes mellitus, dyslipidemia, obesity, or hypertension), were considered eligible for inclusion.

Inclusion Criteria:
- Age ≥ 18 years
- Confirmed diagnosis of at least one metabolic comorbidity (T2DM, dyslipidemia, hypertension, or obesity)
- Willing to provide written informed consent
- Available clinical records and biochemical investigations

Exclusion Criteria:
- Patients with acute infections, malignancy, autoimmune disorders, or end-stage organ disease of non-metabolic etiology
- Pregnant or lactating women
- Patients on chronic corticosteroid or immunosuppressive therapy
- Incomplete clinical or laboratory data
- Refusal to participate

Sample Size Calculation
The sample size was calculated using the formula for estimating a proportion:

$$n = \frac{Z^2 \times p(1-p)}{d^2}$$

Where:
- Z = 1.96 (at 95% confidence interval)
- p = 0.75 (estimated prevalence of hypertension as the most common metabolic comorbidity, based on prior literature)
- d = 0.08 (allowable margin of error, 8%)

$$n = \frac{(1.96)^2 \times 0.75 \times 0.25}{(0.08)^2} = \frac{3.8416 \times 0.1875}{0.0064} \approx 113$$

Accounting for a 10% non-response and dropout rate, the final sample size was rounded to **120 patients**, which were consecutively enrolled during the study period.

Data Collection
After obtaining written informed consent, a structured, pre-tested proforma was used to record:
- **Socio-demographic details:** age, gender, residence (urban/rural), and socio-economic status (classified per modified BG Prasad scale)
- **Clinical history:** duration and type of metabolic comorbidities, current medications, and history of organ-related complications
- **Anthropometric measurements:** height, weight, and BMI calculated as weight (kg) divided by height squared (m²); obesity defined as BMI ≥ 30 kg/m², and overweight as BMI 25–29.9 kg/m²

Biochemical Investigations
All patients underwent standardized biochemical evaluation after an overnight fast of 8–10 hours. Investigations included:
- **HbA1c** (glycated hemoglobin, %) — assessed by high-performance liquid chromatography (HPLC)
- **Fasting lipid profile** — total cholesterol, triglycerides, LDL, and HDL (enzymatic colorimetric method)
- **Serum creatinine** (mg/dL) — for renal function assessment
- **Systolic and diastolic blood pressure** (mmHg) — recorded in a resting seated position on two separate occasions; mean value used

Normal reference ranges applied were: BMI 18.5–24.9 kg/m², HbA1c < 5.7%, total cholesterol < 200 mg/dL, triglycerides < 150 mg/dL, serum creatinine 0.7–1.3 mg/dL, and systolic BP < 120 mmHg.

Diagnostic Criteria

- **Type 2 Diabetes Mellitus:** HbA1c ≥ 6.5% or fasting plasma glucose ≥ 126 mg/dL or prior physician diagnosis with ongoing treatment (ADA 2021 criteria)
- **Hypertension:** systolic BP ≥ 140 mmHg and/or diastolic BP ≥ 90 mmHg on two separate readings or prior diagnosis with antihypertensive therapy (JNC 8 guidelines)
- **Dyslipidemia:** total cholesterol ≥ 200 mg/dL and/or triglycerides ≥ 150 mg/dL and/or LDL ≥ 130 mg/dL and/or HDL < 40 mg/dL in males and < 50 mg/dL in females (NCEP-ATP III criteria)
- **Metabolic Syndrome:** diagnosed using the harmonized IDF/AHA/NHLBI joint interim criteria (Alberti et al., 2009) — presence of any three of five components: elevated waist circumference, elevated triglycerides, reduced HDL, raised blood pressure, and elevated fasting glucose
- **Chronic organ disease** was diagnosed based on established clinical and laboratory criteria for CKD (KDIGO guidelines), CAD (electrocardiographic and echocardiographic evidence), NAFLD (ultrasonographic hepatic steatosis), COPD (spirometric criteria), and prior cerebrovascular accident (clinical history and neuroimaging)

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using free statistical calculator. Categorical variables were expressed as frequency and percentage. Continuous variables were expressed as mean ± standard deviation (SD). The association between the number of metabolic conditions and presence of chronic organ disease was tested using the Chi-square test. A p-value of < 0.05 was considered statistically significant.

Results- A total of 120 patients were enrolled in the study. The majority belonged to the 41–60 years age group (45.0%), were male (56.7%), resided in urban areas (61.7%), and belonged to the middle socio-economic strata (51.7%) (Table 1). Among metabolic comorbidities, hypertension was the most prevalent (75.0%), followed by Type 2 Diabetes Mellitus (68.3%), dyslipidemia (63.3%), and metabolic syndrome (48.3%), while obesity (BMI ≥ 30 kg/m²) and overweight were noted in 36.7% and 31.7% of patients, respectively (Table 2). Regarding chronic organ involvement, Non-Alcoholic Fatty Liver Disease (NAFLD) was the most common finding (35.0%), followed by Chronic Kidney Disease (26.7%), Coronary Artery Disease (23.3%), COPD (10.0%), and prior stroke (8.3%) (Table 3). Biochemical and anthropometric assessment revealed a mean BMI of 28.4±4.228.4±4.2kg/m², mean HbA1c of 7.8±1.47.8±1.4%, mean total cholesterol of 215 ±35215±35 mg/dL, triglycerides of 185±50185±50 mg/dL, serum creatinine of 1.4± 0.61.4±0.6 mg/dL, and mean systolic blood pressure of 142±18142±18 mmHg, all exceeding their respective normal reference ranges (Table 4). A statistically significant stepwise increase in chronic organ disease was observed with a rising number of metabolic conditions — affecting 18.2% of patients with one condition, 39.1% with two conditions, and 69.2% with three or more conditions ($p < 0.05$), indicating a strong cumulative metabolic burden on end-organ health (Table 5).

Table 1: Socio-Demographic Profile of the Study Population

Variable	Sub-category	Frequency (n=120)	Percentage (%)
Age Group	18–40 years	30	25.0%
	41–60 years	54	45.0%
	> 60 years	36	30.0%
Gender	Male	68	56.7%
	Female	52	43.3%

Residence	Urban	74	61.7%
	Rural	46	38.3%
Socio-economic Status	Low	28	23.3%
	Middle	62	51.7%
	High	30	25.0%

Table 2: Distribution of Metabolic Comorbidities

Comorbidity	Number of Patients (n)	Percentage (%)
Diabetes Mellitus (Type 2)	82	68.3%
Dyslipidemia	76	63.3%
Obesity (BMI $\ge$ 30 kg/m^2)	44	36.7%
Overweight (BMI 25–29.9 kg/m^2)	38	31.7%
Hypertension	90	75.0%
Metabolic Syndrome*	58	48.3%

Table 3: Prevalence of Chronic Organ Disease

Organ System Involvement	Number of Patients (n)	Percentage (%)
Chronic Kidney Disease (CKD)	32	26.7%
Coronary Artery Disease (CAD)	28	23.3%
Non-Alcoholic Fatty Liver Disease (NAFLD)	42	35.0%
Chronic Obstructive Pulmonary Disease (COPD)	12	10.0%
Cerebrovascular Accident (Stroke History)	10	8.3%

Table 4: Biochemical and Anthropometric Parameters

Parameter	Mean ± SD	Normal Range
Body Mass Index (BMI)	28.4± 4.2 kg/m^2	18.5–24.9
HbA1c	7.8±1.4 %	< 5.7%
Total Cholesterol	215 ± 35 mg/dL	< 200 mg/dL
Triglycerides	185 ± 50mg/dL	< 150 mg/dL
Serum Creatinine	1.4± 0.6mg/dL	0.7–1.3 mg/dL
Systolic BP	142 ± 18mmHg	< 120 mmHg

Table 5: Correlation between Number of Metabolic Hits and Organ Disease

Number of Metabolic Conditions*	Patients (n)	Chronic Organ Disease Present (n)	p-value
1 Condition	22	4 (18.2%)	< 0.05
2 Conditions	46	18 (39.1%)	
3 or More Conditions	52	36 (69.2%)	
Total	**120**	**58**	

Discussion

The present study was undertaken to evaluate the prevalence of metabolic comorbidities and their association with chronic organ disease among hospitalized adults. A total of 120 patients were enrolled, and the findings revealed a high burden of overlapping metabolic conditions with a statistically significant cumulative impact on end-organ health.The predominance of patients in the 41–60 years age group (45.0%) is consistent with the well-established peak incidence of metabolic disorders in middle-aged adults, a trend widely reported across Indian hospital-based studies. Mohan et al.[10] documented a similar age distribution in their landmark epidemiological study on type 2 diabetes in Indian adults, confirming middle age as the period of highest metabolic

vulnerability. The higher proportion of male patients (56.7%) aligns with findings by Misra et al.,[1] who reported a male preponderance among hospitalized patients with metabolic syndrome, attributing this to greater occupational stress and higher exposure to lifestyle risk factors including tobacco use, alcohol consumption, and physical inactivity. The preponderance of urban residents (61.7%) reflects the well-documented epidemiological transition associated with urbanization. Pradeepa et al.[5] similarly observed a significantly higher prevalence of metabolic comorbidities in urban compared to rural populations in the ICMR-INDIAB study, attributing this to calorie-dense diets and sedentary behavior. The higher prevalence of middle socio-economic status patients (51.7%) is consistent with studies by Gupta et al.,[11] indicating that this group faces a double burden — insufficient access to preventive healthcare while experiencing escalating lifestyle-related disease risk. Hypertension was the most prevalent comorbidity in our cohort (75.0%), followed by T2DM (68.3%) and dyslipidemia (63.3%). This pattern is concordant with findings reported by Anchala et al.[12] in their systematic review and meta-analysis on hypertension in India, which estimated an overall hypertension prevalence of 29.8% in the general population, with substantially higher rates among hospitalized cohorts. The co-occurrence of diabetes and hypertension in a significant proportion of patients is particularly concerning, as Sowers et al.[13] demonstrated that this combination synergistically accelerates cardiovascular and renal injury through shared mechanisms including endothelial dysfunction, renin-angiotensin-aldosterone system (RAAS) activation, and oxidative stress. Metabolic syndrome was present in 48.3% of patients, a figure comparable to the 47.2% reported by Prasad et al.[14] in a hospital-based study of adults with metabolic disorders from central India. The prevalence of obesity (36.7%) and overweight (31.7%) collectively indicated that over two-thirds of the study population had excess body weight, consistent with findings by Misra et al.,[1] who reported a rising trend of adiposity-driven metabolic dysfunction across urban Indian populations.The mean values of all biochemical and anthropometric parameters exceeded their respective normal reference ranges. The mean BMI of 28.4 ± 4.2 kg/m² placed the average patient in the overweight category, consistent with the findings of Vikram et al.,[15] who reported a mean BMI of 27.8 ± 3.9 kg/m² among north Indian patients with metabolic syndrome. The mean HbA1c of $7.8 \pm 1.4\%$ reflected suboptimal glycemic control — a well-recognized predictor of microvascular and macrovascular complications, as extensively documented by the UK Prospective Diabetes Study (UKPDS) Group, which showed that each 1% reduction in HbA1c was associated with a 37% reduction in microvascular complications.[16] Elevated mean total cholesterol (215 ± 35 mg/dL) and triglycerides (185 ± 50 mg/dL) indicate widespread atherogenic dyslipidemia, comparable to the lipid profiles reported by Joshi et al.[17] in their multicenter study on dyslipidemia in Indian patients with type 2 diabetes. The mean serum creatinine of 1.4 ± 0.6 mg/dL, exceeding the upper normal limit, suggests subclinical or overt renal impairment, in agreement with Agarwal et al.,[18] who reported elevated creatinine levels as an early marker of cardiometabolic kidney injury in hospitalized adults. The mean systolic BP of 142 ± 18 mmHg is consistent with Stage 1–2 hypertension and closely aligns with values reported by Ramakrishnan et al.[19] in their study on cardiovascular risk profiling in Indian urban adults. NAFLD was the most common chronic organ complication identified (35.0%), followed by CKD (26.7%) and CAD (23.3%). The high prevalence of NAFLD is consistent with findings by Duseja et al.,[20] who reported a NAFLD prevalence of 32.0% among Indian patients with metabolic syndrome and attributed it to the strong pathophysiological links with insulin resistance, central obesity, and dyslipidemia. NAFLD represents the hepatic manifestation of metabolic syndrome and, as highlighted by Targher et al.,[21] is increasingly recognized not only as a liver disease but also as an independent cardiovascular risk factor through mechanisms involving systemic inflammation and atherogenic dyslipidemia. CKD was present in 26.7% of patients, which is in keeping with data published by Singh et al.,[22] who documented that diabetic nephropathy and hypertensive nephrosclerosis account for over 60% of CKD cases in India. CAD, affecting 23.3% of patients, reflects the additive cardiovascular risk conferred by the metabolic risk factor cluster, a finding corroborated by Gupta et al.,[14] who reported a 22.6% prevalence of CAD in a comparable

hospitalized metabolic cohort from northern India. COPD (10.0%) and prior cerebrovascular accident (8.3%), though less prevalent, further illustrate the systemic multi-organ impact of chronic metabolic disease, consistent with the multimorbidity framework described by Barnett et al.[23]

The most clinically significant finding of this study was the dose-dependent relationship between the number of metabolic conditions and the prevalence of chronic organ disease. Organ involvement was noted in 18.2% of patients with a single metabolic condition, rising to 39.1% with two conditions and 69.2% with three or more conditions ($p < 0.05$). This stepwise escalation supports the concept of "metabolic hits," wherein each additional metabolic risk factor amplifies systemic inflammation, oxidative stress, and endothelial injury, collectively precipitating or accelerating organ damage. This pattern closely parallels findings by Isomaa et[24] al., who demonstrated in the Botnia study that individuals with metabolic syndrome had a threefold higher cardiovascular mortality and a significantly greater prevalence of nephropathy and retinopathy compared to those without the syndrome. Alberti et al.[9] similarly emphasized that the clustering of metabolic risk factors confers a risk to target organs that exceeds the sum of individual contributions. These findings have important clinical implications — they reinforce the need for early, simultaneous, and aggressive management of all coexisting metabolic conditions rather than treating each in isolation. Integrated care models targeting the entire metabolic risk profile, as advocated by Mohan et al.,[10] may be substantially more effective in preventing end-organ complications than single disease-specific approaches.

Conclusion

The present study demonstrates a high prevalence of overlapping metabolic comorbidities — particularly hypertension, type 2 diabetes mellitus, and dyslipidemia — among hospitalized adults, with a significant proportion exhibiting excess body weight and suboptimal biochemical parameters. NAFLD, CKD, and CAD emerged as the most common chronic organ complications. Importantly, a statistically significant dose-dependent relationship was observed between the cumulative number of metabolic conditions and the presence of chronic organ disease, with patients carrying three or more metabolic conditions showing organ involvement in nearly 70% of cases. These findings underscore the need for early identification, simultaneous management, and integrated multidisciplinary care of all coexisting metabolic risk factors to prevent or delay end-organ damage. Public health strategies must prioritize metabolic screening programs, lifestyle modification interventions, and strengthening of community-level chronic disease management to reduce the growing burden of metabolic multimorbidity in India.

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