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Prediabetes and Fatty Liver: A Cross-Sectional Study to Assess the Frequency and Severity of Fatty Liver Detected During Preventive Abdominal Ultrasonography and Their Association with HbA1c

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ABSTRACT

Introduction: Incidental abnormalities are frequently encountered during imaging performed for preventive health assessment. Their clinical importance ranges from negligible findings to abnormalities requiring prompt evaluation. Abdominal ultrasonography is particularly suitable for health-check programs because it is non-invasive, readily available, and free of ionizing radiation. This study assessed the frequency and severity of incidental findings detected during preventive abdominal ultrasonography and examined their association with HbA1c.
Materials and Methods: This retrospective cross-sectional study included adults who underwent abdominal ultrasonography during routine master health check-ups at the Department of Radiology, Panimalar Medical College and Research Institute, Chennai, between January and December 2023. Ultrasound reports were anonymized and reviewed. Incidentally detected fatty liver were classified by ultrasound and subjectively graded as Grade 1 (increased echogenicity), Grade 2 (portal wall echogenicity poorly seen) or Grade 3 (poor visualization of diaphragm and portal vein). Associations with HbA1c were assessed using descriptive statistics, Pearson correlation, chi-square testing, and multivariable logistic regression in SPSS version 25.0.
Results: Of 2,312 participants, 1,315 (56.9%%) had fatty liver. The most frequently reported abnormalities included fatty liver (56.9%), renal cysts (7.8%), and gallstones (5.9%). In the study dataset, 61% were assigned to the normoglycemic group and 39% to the prediabetic group according to the HbA1c categorization. Age and HbA1c were reported as significant predictors of Grade 3 findings. In the fatty-liver model, each one-unit increase in HbA1c was associated with an approximately 10.5% increase in odds of fatty liver (p=0.004).
Conclusion: Incidental fatty liver was common in adults undergoing preventive abdominal ultrasonography. Fatty liver, renal cysts, and gallstones were among the commonest findings. Higher HbA1c and older age were associated with clinically significant findings, while sex was

not identified as a significant predictor. Standardized reporting and follow-up pathways may improve the clinical utility of preventive imaging.

Keywords: *abdominal ultrasonography; incidental findings; preventive health check-up; HbA1c; diabetes mellitus; fatty liver; renal cyst; gallstones*

INTRODUCTION

Incidental findings are abnormalities identified during imaging that are unrelated to the examination's clinical indication. Their frequency varies by imaging modality, population, and definition, and they may create both clinical opportunities and downstream diagnostic burden. Systematic reviews show that incidental findings are common across diagnostic imaging and that their clinical consequences vary widely. [1,2]

Abdominal ultrasonography is widely used in preventive health assessments because it is non-invasive, does not expose patients to ionizing radiation, and can evaluate multiple abdominal organs in a single examination. Incidental abnormalities may therefore be detected in individuals without relevant symptoms. The challenge is to distinguish findings that can be documented from those that warrant additional imaging, laboratory assessment, specialist referral or urgent management. [3]

The increasing burden of type 2 diabetes in India provides an important metabolic context for abdominal imaging. Diabetes commonly coexists with obesity, dyslipidemia and hypertension and is associated with abnormalities involving the liver, biliary system, kidneys and pancreas. [4-8] Ultrasonographic studies have reported associations between diabetes and fatty liver, gallstone disease, altered renal morphology, and increased pancreatic echogenicity. [5-10]

This study aimed to determine the prevalence and distribution of incidental findings detected on abdominal ultrasonography during preventive health check-ups, classify these findings according to clinical significance, compare their distribution between the study's HbA1c-defined groups, and identify predictors of clinically significant findings. Particular attention was given to the relationship between HbA1c and fatty liver.

MATERIALS AND METHODS

Study Design and Setting

A retrospective cross-sectional study was conducted in the Department of Radiology, Panimalar Medical College and Research Institute, Chennai. Medical records of adults who underwent abdominal ultrasonography as part of a routine master health check-up between January and December 2023 were retrospectively reviewed. A total of 2,312 ultrasound examinations were included in the study.

Eligibility Criteria

Individuals aged >18 years who underwent abdominal ultrasonography as part of the specified health check-up were eligible for inclusion. Participants with previously documented abnormalities and those who were symptomatic for an active illness at the time of the health check-up were excluded.

Ethical Considerations

The study was conducted following approval from the Institutional Ethics Committee. As the study involved retrospective analysis of anonymized data, the requirement for individual informed consent was waived by the Ethics Committee.

Ultrasound Assessment and Classification

Ultrasound reports were retrospectively reviewed, and all patient-identifying information was removed before analysis. Incidental ultrasound findings were categorized according to the organ system involved, including the hepatobiliary system, pancreas, kidneys, spleen, urinary bladder, pelvis, anterior abdominal wall, bowel, and mesentery.

The incidental findings were classified into three grades according to their clinical significance:

Grade 1: Findings considered clinically insignificant or of low clinical significance, for which no additional evaluation was considered necessary.

Grade 2: Indeterminate findings requiring further evaluation by appropriate imaging, laboratory investigation, or clinical assessment.

Grade 3: Potentially serious findings requiring prompt clinical attention, for which appropriate imaging, laboratory evaluation, or clinical assessment was recommended.

HbA1c Categorization

HbA1c values available in the health-check records were analyzed in relation to the incidental ultrasound findings. Based on the categorization used in the original study dataset, participants were divided into two study-defined groups: those with HbA1c ≥5.8% and those with HbA1c <5.8%.

The HbA1c threshold of 5.8% was used solely as a study-defined categorization and was not considered a standard diagnostic threshold for diabetes mellitus or prediabetes. The American Diabetes Association diagnostic criterion for diabetes mellitus is an HbA1c value of ≥6.5% when measured using an appropriate standardized assay. [11] Therefore, the HbA1c categorization used in this study should be interpreted in the context of the original study protocol and laboratory methodology.

Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics version 25.0. Continuous variables were summarized using mean and standard deviation, whereas categorical variables were expressed as frequencies and percentages.

The chi-square test was used to assess the association between the predefined HbA1c categories and the distribution of incidental ultrasound findings. Where appropriate, continuous variables were compared between groups using suitable parametric or non-parametric tests based on the distribution of the data.

Multivariable logistic regression analysis was performed to identify factors independently associated with Grade 3 incidental ultrasound findings. Age, sex, and HbA1c category were included as explanatory variables. The strength of association was expressed as odds ratios (ORs) with corresponding 95% confidence intervals (CIs). The p-value of <0.05 was considered statistically significant.

RESULTS

The total number of patients who underwent an abdominal ultrasound abdomen as part of their routine health checkups was 2312, of which 1477 (64%) had one or more incidental abnormal findings. (Figure 1)

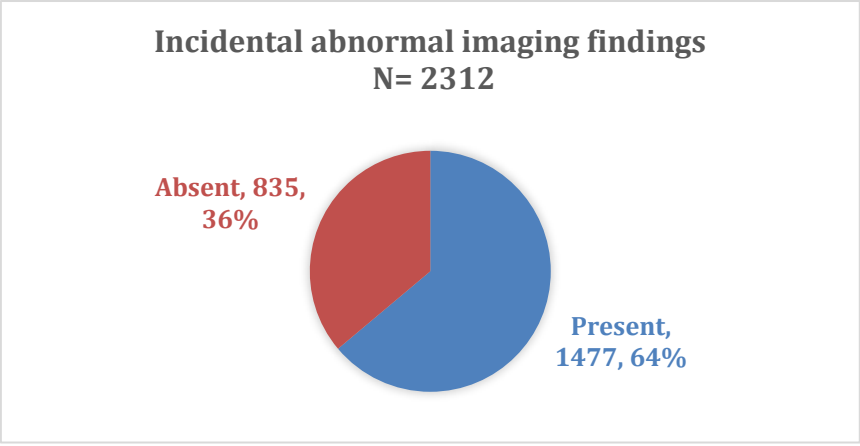


Figure 1: Prevalence of Incidental abnormal findings in imaging

Table 1: Baseline Characteristics

Parameter	Total no of participants n=1477 (%)

AGE (Mean (SD))	49.30 (12.5)
Gender Female Male	 668 (45.2%) 809 (54.8%)
HbA1C (Mean (SD))	**7.06 (2.1)**

The table 1 provides the baseline characteristics of the participants in the study. The total number of participants is 1477. The mean age is 49.30 years with a standard deviation of 12.5 years. The gender distribution is 45.2% female and 54.8% male. The mean HbA1C is 7.06 with a standard deviation of 2.1, indicating the average blood sugar level among the participants.

Table 2: Distribution of system-wise Severity

System	Less Significant (1)		Indeterminate (2)		Emergency (3)		Total
	N	%	N	%	N	%	
LIVER	993	97.07	25	2.44	5	0.49	1023
GALL BLADDER	2	1.56	125	97.65	1	0.78	128
PANCREAS	0	0	4	100	0	0	4
KIDNEYS	107	40.68	125	47.52	31	11.78	263
SPLEEN	0	0	52	100	0	0	52
BLADDER	0	0	63	96.98	2	3.07	65
PELVIS	8	1.048	730	95.67	25	3.27	763

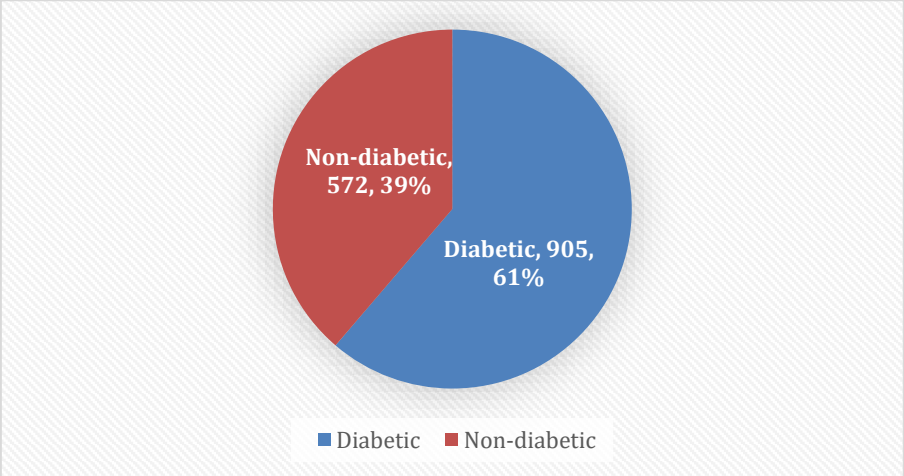


Figure 2: Prevalence of Diabetes in the study population

As shown in table 2; in the liver, the majority of cases are classified as less significant (97.07%), with a small percentage being indeterminate (2.44%) and an even smaller percentage falling under the emergency category (0.49%). In contrast, the gall bladder has a strikingly different distribution, with almost all cases being indeterminate (97.65%), and very few categorized as either less significant (1.56%) or emergency (0.78%).

The pancreas shows a unique pattern, with 100% of cases falling under the indeterminate category, and none classified as less significant or emergency. The kidneys exhibit a more diverse distribution, with 40.68% of cases being less significant, 47.52% indeterminate, and 11.78% emergency.

Interestingly, the spleen's cases are all indeterminate (100%), similar to the pancreas, with no cases in the other categories. The bladder follows a pattern where nearly all cases are indeterminate (96.98%), with a small proportion falling into the emergency category (3.07%).

The pelvis shows a high percentage of indeterminate cases (95.67%) but also has a

noticeable proportion of emergency cases (3.27%), with very few classified as less significant (1.048%). The 'Others' category shows a more balanced distribution with 4.96% of cases being less significant, 42.85% indeterminate, and a significant 52.17% classified as emergency.

Table 3: Comparison of Frequency of Incidental Findings in Non-Diabetic and Diabetic Groups

System	Severity	Diabetic N	Diabetic %	Non-Diabetic N	Non-Diabetic %	Total	p-value
LIVER	Less Significant	500	50.00%	493	49.00%	993	**0.000**
	Indeterminate	12	48.00%	13	52.00%	25	
	Emergency	3	60.00%	2	40.00%	5	
GALL BLADDER	Less Significant	1	50.00%	1	50.00%	2	0.612
	Indeterminate	60	48.00%	65	52.00%	125	
	Emergency	1	50.00%	1	50.00%	2	
PANCREAS	Indeterminate	4	100.00%	0	0.00%	4	0.676
KIDNEYS	Less Significant	43	40.68%	64	59.32%	107	0.386
	Indeterminate	59	47.53%	66	52.47%	125	
	Emergency	18	58.06%	13	41.94%	31	
SPLEEN	Less Significant	0	0.00%	52	100.00%	52	0.401
BLADDER	Indeterminate	61	96.92%	2	3.08%	63	0.424
	Emergency	0	0.00%	2	100.00%	2	
PELVIS	Less Significant	2	1.05%	181	98.95%	183	0.800
	Indeterminate	79	95.67%	4	4.33%	83	
	Emergency	8	4.22%	181	95.78%	189	

As shown in the table 3; in the liver, the majority of findings are classified as less significant, with a nearly equal split between diabetic (50.00%) and non-diabetic (49.00%) groups. The difference in this distribution is statistically significant with a p-value of 0.000. For indeterminate cases, the distribution is slightly skewed towards non-diabetic individuals (52.00%), while in emergency cases, the diabetic group has a higher percentage (60.00%).

For the gall bladder, there is an equal distribution of less significant and emergency findings between the two groups (50.00% each). Indeterminate cases show a slight preference towards non-diabetic individuals (52.00%), but the overall differences are not statistically significant (p-value = 0.612).

In the pancreas, all cases are indeterminate, with all findings in the diabetic group (100.00%). This stark difference, however, is not statistically significant (p-value = 0.676).

Kidneys show a more varied distribution, with less significant findings more common in non-diabetics (59.32%), but the difference is not statistically significant (p-value = 0.386). Indeterminate cases are almost evenly distributed, and emergency cases are more prevalent in diabetics (58.06%).

For the spleen, all less significant findings are in the non-diabetic group, but the difference is not statistically significant (p-value = 0.401).

The bladder shows a significant skew towards the indeterminate category, with most cases in the diabetic group (96.92%), although this difference is not statistically significant (p-value = 0.424).

In the pelvis, less significant findings are overwhelmingly more common in non-diabetics (98.95%), but this difference is not statistically significant (p-value = 0.800). Indeterminate cases are almost entirely in the diabetic group (95.67%).

The comparison of findings across various organ systems between non-diabetic and diabetic groups reveals a notable trend where diabetic individuals generally exhibit a higher prevalence of various conditions. In the liver, fatty liver is significantly more common among diabetics, as are cases of fatty liver grade III and hepatomegaly. Gall bladder issues such as cholelithiasis also show a higher incidence in diabetics, whereas findings like GB polyps are more

frequent in non-diabetics. The pancreas, kidneys, and spleen all show a similar pattern, with conditions such as pancreatitis, renal cysts, CKD, and splenomegaly being more prevalent in diabetic patients. The bladder and pelvis findings, including cystitis and prostatomegaly, further reflect this trend, with diabetic individuals showing higher rates of these conditions. (Table 4)

Table 4: Frequencies of Findings in organ/system

Organ/System	Non-Diabetic N	Diabetic N	Counts	% of Total
Liver				
Fatty liver	39	118	157	10.6%
Fatty liver grade III, Hepatomegaly	290	551	841	56.9%
granuloma, cyst, hemangioma	7	9	16	1.1%
thrombosis	2	1	3	0.2%
CLD	3	3	6	0.4%
Gall Bladder				
cholelithiasis	32	55	87	5.9%
calculous cholecystitis	3	5	8	0.5%
GB polyp	17	8	25	1.7%
adenomyomatosis, choledochal cyst	6	3	9	0.6%
PANCREAS - Pancreatitis	1	3	4	0.3%
KIDNEYS				
renal cyst	43	72	115	7.8%
calculus, hydronephrosis	5	12	17	1.2%
CKD	19	32	51	3.5%
ectopic, absence, horseshoe	37	36	73	4.9%
SPLEEN - Splenomegaly	21	31	52	3.5%
BLADDER				
cystitis	27	32	59	4.0%
calculus, diverticulum	1	5	6	0.4%
PELVIS				
Prostatomegaly (Males)	72	111	183	12.4%
ovarian pathologies (Females)	30	53	83	5.6%
uterine/endometrial pathology (Females)	69	120	189	12.8%
OTHERS				
hernia	31	41	72	4.9%
obstruction	9	5	14	0.9%
scrotal, free fluid, ascites		1	1	0.1%

The correlation analysis between incidental findings and HbA1c levels reveals varying degrees of association across different organ systems. For liver-related findings, there is a weak negative correlation with HbA1c levels, particularly for fatty liver and related conditions such as hepatomegaly, with a correlation coefficient of -0.153 and a statistically significant p-value of 0.000. This suggests that as HbA1c levels increase, the likelihood of these liver conditions may slightly decrease, though the effect size is small. (Table 5)

Table 5: Correlation of liver incidental findings with HbA1c levels

Finding	Count	% of Total	Correlation with HbA1c	p-value
Liver				
Fatty liver	157	10.6		
Fatty liver grade III, Hepatomegaly	841	56.9	-0.153	0.000
granuloma, cyst, hemangioma	16	1.1		
thrombosis	3	0.2		
CLD	6	0.4		

The logistic regression analysis for fatty liver indicates that among the variables considered, HbA1C levels are significantly associated with the likelihood of developing fatty liver. Specifically, each unit increase in HbA1C increases the odds of having fatty liver by approximately 10.5%, a relationship that is statistically significant with a p-value of 0.003. In contrast, age shows a slight, non-significant decrease in the odds of fatty liver as it increases, and the effect of being male, while suggesting a trend towards higher risk, is not statistically significant either. (Table 6) 96.6% of participants did not require follow-up imaging, while 3.4% did as seen in table 7

Table 6: Logistic regression for Fatty liver

Variable	Coefficient	Standard Error	z-value	95% CI Lower Bound	95% CI Upper Bound
AGE	-0.010	0.007	-1.391	0.164	-0.023
HbA1C	0.105	0.035	2.984	0.003	0.036
SEX (Males)	0.282	0.174	1.626	0.104	-0.058

Table 7: Frequencies of Follow-up/IMAGING

Follow-up/IMAGING	Counts	% of Total
NO	1427	96.6%
YES	50	3.4%

DISCUSSION

This study aimed to evaluate the prevalence and distribution of incidental findings in imaging among diabetic and non-diabetic patients, and to identify predictors of significant incidental findings. The results revealed no statistically significant differences in the distribution of incidental findings between diabetic and non-diabetic patients across different organ systems. Additionally, age and HbA1c values were significant predictors of significant incidental findings, while gender was not.

The prevalence of incidental findings in our study, with 64% of patients exhibiting one or more abnormalities during routine ultrasound imaging, is consistent with the high incidence of such findings reported in populations with metabolic conditions, particularly diabetes and obesity. This is corroborated by Lizardi-Cervera and Aguilar-Zapata [11], who observed that nonalcoholic fatty liver disease (NAFLD) was present in up to 70% of patients with obesity and diabetes. Similarly, Younossi et al. [12] found that the global prevalence of NAFLD was around 25%, but significantly higher in individuals with metabolic syndrome, reinforcing our findings that 56.9% of diabetic patients in our study had fatty liver. These findings highlight the strong association between metabolic disorders and liver abnormalities, as seen in our logistic regression analysis, where each unit increase in HbA1C raised the odds of fatty liver by approximately 10.5%.

Our study's results, indicating that the liver was the most commonly affected organ with a majority of findings classified as less significant, align with established knowledge regarding the high prevalence of liver conditions in diabetic and obese populations. Younossi et al. [12] reported that NAFLD is not only prevalent but also closely associated with metabolic syndrome, which is reflected in our findings. The observed association between higher HbA1C levels and fatty liver further substantiates the connection between glycemic control and liver health, a relationship that has been well documented in the literature [12].

In terms of gallbladder findings, our study observed that most abnormalities were indeterminate, which is consistent with the findings of Festi et al. [13] and Méndez-Sánchez et al. [14]. Festi et al. [13] noted that gallbladder motility disorders, including gallstones, were significantly more common in diabetic patients, with gallbladder emptying impaired in up to 50% of cases. Méndez-Sánchez et al. [14] identified diabetes as a key risk factor for gallstone disease, particularly in the Mexican population. These findings are mirrored in our study,

where cholelithiasis was more prevalent among diabetic participants, reflecting the known association between diabetes and gallbladder disease.

The high percentage of indeterminate findings in the pancreas, kidneys, and spleen in our study also aligns with existing research. Afkarian et al. [15] reported that chronic kidney disease (CKD) was present in approximately 40% of individuals with type 2 diabetes, a finding that correlates with the 47.52% of indeterminate kidney findings in our study, along with 11.78% categorized as emergencies. Furthermore, Yadav and Lowenfels [16] observed an increased incidence of pancreatitis in diabetic patients, which supports our findings of pancreatitis among diabetic participants, albeit in a smaller subset of cases.

The high rate of indeterminate findings in organs such as the gallbladder, pancreas, and spleen highlights the need for standardized guidelines on managing incidental findings, particularly in patients with chronic conditions like diabetes. The lack of significant correlations between HbA1C and most incidental findings suggests that while diabetes is a risk factor for certain conditions, its impact may not be uniform across all organ systems. Additionally, the discrepancy between our findings and some previous studies underscores the importance of context-specific research, as differences in study populations and methodologies can lead to varying results.

Moreover, the fact that 96.6% of participants did not require follow-up imaging indicates that most incidental findings may not necessitate immediate intervention. However, the potential for significant findings in a minority of patients underscores the importance of thorough evaluation and appropriate follow-up.

Future research should focus on prospective, multicenter studies to enhance the generalizability of the findings and reduce selection bias. Longitudinal studies are needed to assess the long-term outcomes and clinical significance of incidental findings in both diabetic and non-diabetic populations. Including a broader range of covariates, such as detailed lifestyle factors, comorbidities, and genetic predispositions, could provide a more comprehensive understanding of the predictors and implications of incidental findings. Additionally, developing standardized protocols for the management and follow-up of incidental findings could help optimize patient care and resource utilization.

CONCLUSION

Incidental abnormalities were frequent among adults undergoing preventive abdominal ultrasonography. Fatty liver, renal cysts and gallstones were among the most common findings. Although several abnormalities were more frequent in the study-defined diabetic group, most organ-system comparisons did not demonstrate statistically significant differences. Higher HbA1c was associated with fatty liver, and age and HbA1c were reported as predictors of clinically significant findings. Standardized classification, documentation and follow-up of incidental abnormalities may improve the effectiveness of preventive health-check imaging. Prospective multicenter studies with complete clinical follow-up are needed to validate these findings.

Declaration

Ethical Approval: The study received approval from the institutional ethics committee. The retrospective use of anonymized records permitted waiver of informed consent, according to the source manuscript.

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Conflict of Interest: The authors declare no conflict of interest.

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