INTRODUCTION

Vitamin D deficiency (VDD) is a world-wide epidemic with recent estimates indicating more than 50% global population at risk\(^1\). This pandemic of inadequate vitamin D \{VDD and vitamin D insufficiency (VDI)\} has been found in all age groups even in those who are otherwise healthy and are not prone to deficiency\(^2\). In Pakistan, prevalence of VDD has been reported up to 92% in ambulatory patients in various situations\(^3,4\). The discovery of vitamin D receptors (VDR) in almost all the tissues has led to the identification of role of vitamin D in many organ systems of the body, instead of merely associated with bone disorders\(^5\). Vitamin D has also been found to play an important role in the disorders of glucose and insulin metabolism\(^6\). Inverse correlation between serum vitamin D levels and glycaemic levels has been shown in many studies\(^6,7\). Most of this data, however, pertains to Caucasian population while studies in African American have not confirmed these findings and the association between VDD and diabetes mellitus (DM) is quite blurred\(^8\). Asians have a high prevalence of both DM and VDD and the association of these two disorders has been described in studies carried out in Asian living in the West\(^9\). Vitamin D replacement therapy in South Asian patients with diabetes has also been shown to decrease in HbA1c and weight\(^10\). Tehrani et al (2010) has shown that abnormal vitamin D concentrations were more common in South Asians with type 2 DM (T2DM) and diabetic control was inversely related to vitamin D status in South Asian women with T2DM\(^11\). Conversely, Taylor and Wise (1997) have reported that vitamin D replacement may increase the insulin resistance and worsen the glycaemic control in Asians\(^12\).

Pakistan is one of the countries with a very high...
burden of diabetic patients and a very high prevalence of hypovitaminosis D. So present study has been planned to find an association between these two metabolic diseases.

METHODS AND MATERIAL
In this cross sectional study 86 subjects were selected by non-probability convenience sampling out of the patients referred for vitamin D estimation. The sample population consisted of patients with normoglycaemia (NG), impaired fasting glucose (IFG), and DM. NG was defined as Fasting Plasma Glucose (FPG) < 5.6 mmol/L, IFG: 5.6 – 7.0 mmol/L and DM > 7.0 mmol/L (Position Statement-American Diabetic Association-2009). Similarly, on the basis of their 25OHD levels in blood the subjects were clustered in three groups, normal (>31 ng/ml), insufficient (20-31ng/ml) and deficient (<20ng/ml). 25OHD was measured by electrochemiluminescence using Roche Elecsys® Systems while glucose were estimated by routine methods on Roche Hitachi®.

STATISTICAL ANALYSES
The data was recorded in SPSS version 17 and frequencies of various groups of subjects according to Vitamin D status were determined. Comparison of frequencies was carried out using Chi Square test and continuous data was compared by students’ t test i.e. comparison of FPG in various groups of Vitamin D status. Then correlation studies were carried out between FPG and 25OHD levels using Pearson’s Correlation Coefficient. VDD and VDI of vitamin D status groups were combined and IFG and DM of glucose categories were combined and then 2x2 table was constructed for comparison and calculation of Odds Ratio (OR) using chi-square test.

RESULTS
The sample population had a slight female preponderance (53%), while median age was 34 years (range: 19-65 years). DM was more frequent in subjects with VDD (50% i.e. half of the patients with VDD were also having DM) and VDI (31.6%) as compared to subjects with normal vitamin D status (6.1%) (Table-I). Similarly, more patients with IFG were found in VDD (25%) and VDI (26.3%) groups as compared to subjects with normal Vitamin D status (18.6%) (Table-I). This difference was found statistically significant (p<0.001). A gradual worsening of glycaemic condition was found on progressing from normal vitamin D status to insufficiency and deficiency (Figure 1).

DISCUSSION
The association of Vitamin D and DM has been described for more than twenty five years now. Many workers have shown evidence that vitamin D is related to various aspects of glucose metabolism e.g. improving beta-cell function of pancreas, insulin secretion and insulin sensitivity and is one of the most important environmental factors causing T2DM. Our data has shown two significant findings i.e. higher prevalence of IFG and frank DM in patients with VDI and VDD, and a significance correlation of FPG and vitamin D levels. Many cross-sectional studies carried out in Western populations have generally reported an inverse association between vitamin D status and prevalent hyperglycemia. Similar associations between higher fasting plasma glucose levels and vitamin D status were observed in a community-based study of older adults without known diabetes. Expressing this association in another manner, Tahrani et al (2010) has shown that a low
serum 25OHD (<20 ng/ml) was more common in diabetics as compared to controls (83% vs. 70%; p < 0.07). In another study from US, mean 25OHD levels among T2DM patients were found significantly lower than in individuals without T2DM (OR 1.85; 95% CI 1.03 – 3.32; P = 0.038)\textsuperscript{23}. Conversely, in an Indonasian study 81% diabetic were found to be having VDD as compared to 75% non-diabetic (OR: 0.8; 95% CI 0.42 – 1.21; P = 0.46)\textsuperscript{24} whereas our study showed an OR of 3.35 (95% CI: 1.29-8.70). This discrepancy is difficult to explain but is probably due to difference in age of the selected population.

The close association between vitamin status and DM has been further emphasized by the finding that inadequate vitamin D level is an important risk factor for the development of type 2 DM\textsuperscript{25-28}. The intervention studies to improve glycaemic control with certain doses of vitamin D, however, have

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### Table-I. Distribution of various glycaemic groups in subjects with different Vitamin D Status

<table>
<thead>
<tr>
<th>Vitamin D Status</th>
<th>No. of subjects (n=86)</th>
<th>Normoglycaemia (FPG &lt;5.6 mmol/L)</th>
<th>IFG (FPG 5.6 - 7.0 mmol/L)</th>
<th>DM (FPG &gt; 7.0 mmol/L)</th>
<th>Significance levels (Chi square test)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal (&lt;30 ng/ml)</td>
<td>n=59</td>
<td>45 (76%)</td>
<td>11 (18.6%)</td>
<td>3 (5.1%)</td>
<td>Normal and insufficiency group (p &lt; 0.001)</td>
</tr>
<tr>
<td>Insufficiency (20-30 ng/ml)</td>
<td>n=19</td>
<td>8 (42.1%)</td>
<td>5 (26.3%)</td>
<td>6 (31.6%)</td>
<td>Insufficiency and deficiency group (p &lt; 0.001)</td>
</tr>
<tr>
<td>Deficiency (&lt;20 ng/ml)</td>
<td>n=8</td>
<td>2 (25%)</td>
<td>2 (25%)</td>
<td>4 (50%)</td>
<td>Normal and deficiency group (p &lt; 0.001)</td>
</tr>
</tbody>
</table>

*FPG: Fasting Plasma Glucose*  
*IFG: Impaired Fasting Glycaemia*  
*DM: Diabetes Mellitus*

### Table-II. Comparison of Fasting Plasma Glucose Levels in various groups of Vitamin D Status and Correlation Studies between FPG and Vitamin D Levels

<table>
<thead>
<tr>
<th>Vitamin D Status</th>
<th>No. of subjects (n=86)</th>
<th>(FPG mmol/L) (mean±SD)</th>
<th>Significance levels (Independent t-test)</th>
<th>Pearson’s correlation (r-value)</th>
<th>Significance levels (P value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal (&gt;30 ng/ml)</td>
<td>n=59</td>
<td>5.4±2.2</td>
<td>Normal and insufficiency Group (p=NS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insufficiency (20-30 ng/ml)</td>
<td>n=19</td>
<td>6.3±2.3</td>
<td>Insufficiency and Deficiency Group (p=NS)</td>
<td>r = -0.38</td>
<td>P &lt; 0.001</td>
</tr>
<tr>
<td>Deficiency (&lt;20 ng/ml)</td>
<td>n=8</td>
<td>8.1±3.8*</td>
<td>Normal and Deficiency Group (p&lt;0.05)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table-III. Risk Estimate of Vitamin D adequacy in Normal and abnormal glucose levels

<table>
<thead>
<tr>
<th>Odds ratio for glucose level (Normal / abnormal)</th>
<th>OR</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>N of Valid Cases</td>
<td>86</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.359</td>
<td>1.297 – 8.701</td>
</tr>
</tbody>
</table>

The close association between vitamin status and DM has been further emphasized by the finding that inadequate vitamin D level is an important risk factor for the development of type 2 DM\textsuperscript{25-28}.
shown variable results\textsuperscript{9–35}. Beneficial effect of vitamin D on T2DM is needed to be confirmed in large trials specifically designed to test the hypothesis that vitamin D status is a direct contributor to the pathogenesis of T2DM. If such an intervention is clearly shown to be effective this could have substantial public health implications\textsuperscript{31}.

This was the first study in our country in which an association of vitamin D status was studied with various categories of glucose abnormalities but with some limitations e.g. impaired glucose tolerance which is a category of hyperglycaemia based on oral glucose tolerance test could not be studied. Similarly data regarding glycosylated hemoglobin could not be recorded.

CONCLUSIONS
A significant association between diabetes mellitus and vitamin D inadequacy exists which implies that vitamin D deficiency or insufficiency is undesirable in patients with any form of hyperglycaemia.

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REFERENCES


To fight against one’s desires is the greatest of all fights.

Hazrat Ali (R.A)