A Cross-Sectional Study of Vitamin D Deficiency Among Immigrants and Norwegians With Psychosis Compared to the General Population

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Objective: Vitamin D deficiency is common among immigrants, who, as a group, have heightened risk of psychosis. This study aimed to determine vitamin D levels among immigrants and Norwegians with psychosis compared to the general population and their association to clinical characteristics.

Method: This study compared vitamin D levels between immigrants and Norwegians within and between samples of patients with psychosis from a catchment area–based cross-sectional study (2002–2007) with a sample from a population-based health study from the same catchment area (2000–2001). The psychosis sample included patients with a Structured Clinical Interview for *DSM-IV* Axis I disorders diagnosis of psychotic disorder (67 immigrants, 66 Norwegians). The reference sample consisted of 1,046 subjects (177 immigrants, 869 Norwegians). Serum levels of vitamin D were measured by radioimmunoassay, and results were presented as 25-hydroxyvitamin D levels.

Results: Over 80% (n = 55) of immigrant patients with psychosis had insufficient/deficient serum levels of 25-hydroxyvitamin D (< 50 nmol/L). Immigrants had higher rates of 25-hydroxyvitamin D deficiency than Norwegians ($P < .001$). Norwegians with psychosis had lower serum levels of 25-hydroxyvitamin D than Norwegians in the reference sample from the general public ($P < .001$). 25-Hydroxyvitamin D levels correlated with certain negative/depressive symptoms among patients with psychosis.

Conclusions: An alarmingly high percentage of immigrants and Norwegians with psychotic disorders have 25-hydroxyvitamin D deficiency. This has important clinical implications as it suggests possible beneficial effects of vitamin D medication/heliotherapy within this group.

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Vitamin D deficiency is an important health concern for immigrants from regions close to the equator who have moved to higher latitudes, such as the Nordic countries.[1–5] Research on the role of vitamin D has traditionally focused on its function in calcium homeostasis and bone metabolism.[5] The regulation of CYP27B1 in nonrenal tissues generally differs from that of the kidney and may be more substrate dependent. Thus, higher serum levels of 25-hydroxyvitamin D may be needed for the nonclassical actions of vitamin D than those needed for the classical actions of vitamin D on bone metabolites. Likewise, recent results suggest a possible association between vitamin D and mental health. Reduced serum levels of both the active form 1,25-dihydroxyvitamin D and its circulating precursor 25-hydroxyvitamin D were reported among patients with schizophrenia, depression, and/or alcoholism.[7,8] Additionally, low 25-hydroxyvitamin D levels were associated with higher depression scores[9] and psychiatric illness in general.[10] Since several studies have shown a higher risk of psychosis among immigrant populations,[11,12] with the highest risk among persons with darker skin, it has been proposed, but not studied, whether parts of this risk could be associated with vitamin D deficiency as a result of migration to areas with shorter photoperiods.[13]

The current study is based on populations in Norway and aims to determine (1) the rates of vitamin D deficiency among immigrants compared to Norwegians with psychosis, (2) possible differences in vitamin D levels in immigrants and Norwegians with psychosis compared to the general population, and (3) the relationship between vitamin D level and psychotic or affective symptoms in the patient group.

METHOD

Design

The Thematically Organized Psychosis (TOP) study is an ongoing study of severe mental illness. It is a joint collaboration between Oslo University Hospital and the University of Oslo that includes participants from all catchment areas of the health care sectors in the larger metropolitan area (population 485,000). Both inpatients and outpatients were asked for their permission to be referred to the project by their treating clinicians. Inclusion criteria were 18–65 years of age; a *Diagnostic and Statistical Manual of Mental Disorders*, Fourth Edition (*DSM-IV*) diagnosis of schizophrenia or schizophreniform disorder, schizoaffective disorder, bipolar disorder, delusional disorder, or psychotic disorder not otherwise specified; IQ score > 70; and ability to understand and give written consent to research participation. Drug-induced or organic psychoses were exclusion criteria. The TOP study was approved by the Regional Committee for Medical Research Ethics and the Norwegian Data Inspectorate, and the biobank was approved by the Norwegian Directorate of Health.

Table 1. Diagnostic, Clinical, and Sociodemographic Variation Between Immigrants and Norwegians With Psychotic Disorders (TOP sample)

Variable	Immigrant Sample (n = 67)	Norwegian Sample (n = 66)	Test	*P* Value
Diagnosis, n (%)				
Schizophrenia	47 (70)	44 (67)	$\chi^2_1 = 0.187$	NS
Schizoaffective disorder	12 (18)	5 (8)	$\chi^2_1 = 3.185$	NS
Psychosis, other	8 (12)	17 (26)	$\chi^2_1 = 4.159$	.05
GAF score, mean ± SD				
Symptom	39 ± 8	45 ± 13	$t_{106.230} = 2.92$	.005
Function	40 ± 8	46 ± 12.5	$t_{112.298} = 3.43$	.001
Supervised housing, n (%)	20 (30)	14 (21)	$\chi^2_1 = 1.304$	NS
Education, mean ± SD, y[a]	11 ± 2.5	13 ± 2.6	$t_{130} = 3.11$	.005
Married/cohabitant, n (%)	24 (36)	9 (14)	$\chi^2_1 = 8.77$	.005
Actively working, n (%)	10 (15)	14 (21)	$\chi^2_1 = 0.89$	NS

[a]n = 65 for Norwegians.
Abbreviations: GAF = Global Assessment of Functioning, NS = not significant, TOP = Thematically Organized Psychosis study.

Data from the general population were collected from the population-based Oslo Health Study (HUBRO) that was carried out during 2000–2001 in a joint collaboration with the Oslo City Council, the University of Oslo, and the Norwegian Institute of Public Health. The study invited all individuals in Oslo County, from the same catchment areas as the TOP study, born in 1970, 1960, 1955, 1940–1941, and 1924–1925. The comparison group analyzed here is from a supplementary project recruited for a vitamin D substudy performed in the period from May 2000 to January 2001.[14] The HUBRO study protocol was approved by the Regional Committee for Medical Research Ethics and the Norwegian Data Inspectorate.

Samples

TOP sample. Of the 548 participants included in the project from October 2002 to October 2007, the immigrant group in this study consisted of the 74 participants with a diagnosis of schizophrenia or schizophreniform disorder, schizoaffective disorder (narrow schizophrenia spectrum), delusional disorder, brief psychotic disorder, or psychotic disorder not otherwise specified (other psychoses) who originated from areas with longer photoperiods. After removing missing or poor quality blood samples, the final immigrant sample consisted of 67 immigrant participants with dark skin pigmentation: 14 subjects (21%) from the African continent, 50 subjects (75%) from the Asian continent, and 3 subjects (4%) with dark skin pigmentation from South America and southern Europe. They were paired with a sample of patients born in Norway and matched for sex, age, and season of blood sample extraction. For this part of the study, season was defined as fall and winter months (November until April) and spring and summer months (May until October). Table 1 shows clinical and sociodemographic characteristics for the immigrant and Norwegian groups. Norwegians had more years of education and were significantly more likely to have a diagnosis outside of the narrow schizophrenia spectrum, while the immigrant group had more severe symptoms and a lower function level based on the Global Assessment of Functioning (GAF) scale score but were more often married (legal or common-law).

HUBRO sample. The comparison group consisted of 869 participants born in Norway in 1955, 1940, and 1925 (372 men and 497 women) and 177 participants born in Pakistan from all age groups (104 men, median age of 40 years, range 30–75; and 73 women, median age of 40 years, range 30–60).

Immigrant-HUBRO. Since the main HUBRO data were based on the Pakistani immigrants, we also conducted a follow-up analysis that included vitamin D levels collected from 5 different Asian immigrant groups (Turkey, Iran, Pakistan, Sri Lanka, and Vietnam). These data were collected from The Oslo Immigrant Health Study (Immigrant-HUBRO), and description of material and method may be found elsewhere.[3,15]

Measurements

Participants in the TOP study were diagnosed according to the Structured Clinical Interview for *DSM-IV* Axis I disorders (SCID-I) criteria.[16] Current clinical measures were done with the GAF scale (split version),[17] Positive and Negative Syndrome Scale (PANSS) for psychotic symptoms,[18] Inventory of Depressive Symptomatology–Clinician Rated (IDS-C) for depressive symptoms,[19] and Young Mania Rating Scale (YMRS) for manic symptoms.[20] Participants were subject to a general somatic examination, and fasting morning blood samples were retrieved for all participants. Exercise levels were assessed and categorized as light, medium, or hard and dietary habits as healthy, unhealthy, or very unhealthy in terms of both content and regularity. Migration status was based on ethnicity and country of birth.

Serum levels of 25-hydroxyvitamin D for all groups were measured at the Hormone Laboratory, Oslo University Hospital, Aker, by radioimmunoassay (DiaSorin, Stillwater, Minnesota). This assay measures both 25-hydroxyvitamin D_3 and 25-hydroxyvitamin D_2, and the intra-assay and total assay coefficients of variation (CVs) are 6% and 14% (6% and 15% for HUBRO), respectively. Results are presented as levels in 25-hydroxyvitamin D nmol/L as it has been found to be the barometer for vitamin D status.[21] For some analyses, 25-hydroxyvitamin D levels were categorized following McGillivray[22]: < 25 nmol/L is deficient, < 50 nmol/L

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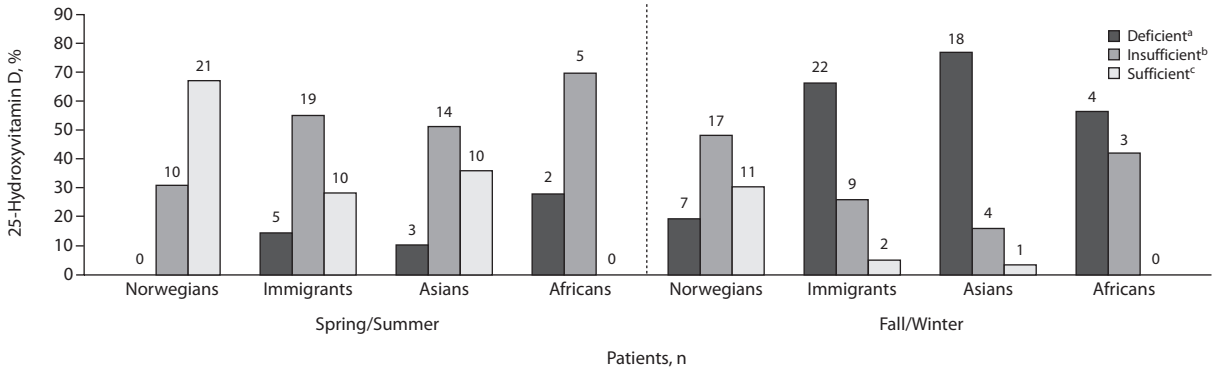
Figure 1. Percent of Insufficient/Deficient Serum Levels of 25-Hydroxyvitamin D Levels in TOP Sample Patients in Relation to Season of Sampling



[a]Deficient < 25 nmol/L.
[b]Insufficient = 26–50 nmol/L.
[c]Sufficient > 51 nmol/L.
Abbreviation: TOP = Thematically Organized Psychosis study.

is insufficient, and > 51 nmol/L is sufficient. Free thyroxin and thyroid-stimulating hormone (TSH) levels were measured at Oslo University Hospital–Ullevål, Department of Clinical Chemistry, on an Integra 800 instrument from Roche Diagnostics (Basel, Switzerland) using standard methods.

Statistics

Statistical analysis was performed using SPSS 16.0 (2007, SPSS Inc, Chicago, Illinois) with a confidence interval of 95% and significance level < .05, 2-sided. Kolomogorov-Smirnov test was nonsignificant for 25-hydroxyvitamin D data among the TOP sample, which suggests normality. Bivariate group differences were analyzed with student *t* tests (Welch correction is reported where equal variance is not assumed) or univariate analyses of variance for continuous variables. Categorical analysis was performed using χ^2 tests. Certain results are reported as percentages to facilitate comparison with earlier research findings.

To analyze which factors could explain 25-hydroxyvitamin D levels from the TOP sample, we conducted hierarchical multiple regression analyses of sociodemographic (immigrant status, age, sex, years of education) and biologic and health measures (season of blood sample, dietary habits, exercise habits, and body mass index [BMI]). Symptom severity and function levels as measured with the split GAF were highly correlated ($r = 0.780$, $P < .001$) and were combined in a mean score to avoid multicollinearity in the multiple regression analyses. The variables of country and year of birth, sex, and season were included in multiple regression analyses of the HUBRO sample.

Pearson correlation was performed to explore association between 25-hydroxyvitamin D level and present affective and psychosis symptoms as scored on PANSS, IDS-C, and YMRS. Partial correlations were conducted to control for possible effect of current depressive episode, free thyroxin levels, and TSH levels on 25-hydroxyvitamin D levels. One participant was excluded from this analysis based on extreme 25-hydroxyvitamin D levels (> 110 nmol/L).

RESULTS

The following results apply to 25-hydroxyvitamin D levels in immigrants and Norwegians with psychosis (TOP sample). The mean ± SD serum level of 25-hydroxyvitamin D in the total TOP sample was 43 ± 22 nmol/L, which is considered insufficient but not defined as deficient.[22] In the whole TOP sample, 26% (n = 34) showed 25-hydroxyvitamin D deficiency, 41% (n = 55) had insufficient levels, and 33% (n = 44) had sufficient levels. We found significant variation in the 25-hydroxyvitamin D levels dependent on the season of blood sampling ($t_{131} = 4.100$, $P < .001$). In spring/summer months (n = 65), 7.7% (n = 5) of patients had 25-hydroxyvitamin D deficiency, while 44.6% (n = 29) had insufficient levels, and in the fall/winter months (n = 68), 80.9% (n = 55) had low 25-hydroxyvitamin D levels (42.6% [n = 29] deficient and 38.2% [n = 26] insufficient levels). Sex did not contribute significantly to these differences.

Immigrants had significantly lower serum levels of 25-hydroxyvitamin D than Norwegians, and this difference was constant independent of season for retrieval of blood sample. In the fall/winter months, the mean ± SD 25-hydroxyvitamin D level for immigrants (26 ± 15) was significantly lower than for Norwegians (45 ± 20; $t_{63.439} = 4.298$, $P < .001$). In the spring/summer months, the 25-hydroxyvitamin D levels were higher, but still significantly lower for immigrants (40 ± 16) compared to Norwegians (62 ± 21; $t_{55.974} = 4.721$, $P < .001$). Both migration status and sampling season had a main effect on serum levels of 25-hydroxyvitamin D ($R^2 = 0.328$, $F_{3,129} = 20.995$, $P < .001$) without interaction effects.

Independent of season of sampling, over 80% (n = 55) of the immigrants had insufficient to deficient 25-hydroxyvitamin D levels (< 50 nmol/L). This is significantly more than that found for the Norwegians ($\chi^2_1 = 14.039$, $P < .001$). However, 52% (n = 34) of the Norwegian sample also had insufficient to deficient 25-hydroxyvitamin D

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Table 2. Mean Serum Level Differences of 25-Hydroxyvitamin D Between Norwegians and Asian Immigrants From the General Population (HUBRO) Compared to Patients With Psychosis (TOP)

Variable	HUBRO, n	Vitamin D Level, mean + SD, nmol/L	TOP, n	Vitamin D Level, mean + SD, nmol/L	t_{df} Test	*P* Value
Total	1,046	66.3 ± 29.1	133	43.1 ± 21.8	$11.10_{1,177}$	.001
Norwegian	869	74.7 ± 23.7	66	52.9 ± 21.9	7.77_{933}	.001
Men	372	74.8 ± 24.4	45	54.0 ± 24.3	5.41_{415}	.001
Women	497	74.7 ± 23.2	21	50.4 ± 15.8	6.74_{516}	.001
Asian	177	25.0 ± 13.6	50	34.1 ± 17.1	-3.48_{225}	.001
Men	104	26.6 ± 12.7	33	31.4 ± 16.1	-1.55_{135}	NS
Women	73	22.5 ± 14.6	17	39.3 ± 18.2	-3.54_{88}	.001

Abbreviations: HUBRO = Oslo Health Study, NS = not significant, TOP = Thematically Organized Psychosis study.

Table 3. Multiple Regression Analysis for Serum Level of 25-Hydroxyvitamin D for TOP and HUBRO Samples

Variable	β	*t* Test	*P* Value[a]
TOP sample			
Constant		9.655	**.001**
Immigrant	−0.463	−6.372	**.001**
Fall/winter	−0.351	−4.823	**.001**
Female	−0.032	−0.434	.665
Age	−0.020	−0.276	.783
HUBRO sample			
Constant		32.865	**.001**
Country of birth	−0.630	−21.994	**.001**
Season	−0.088	−3.704	**.001**
Sex	−0.014	−0.582	.561
Year of birth	−0.014	−0.496	.620

[a]Bolded *P* values denote significance.
Abbreviations: HUBRO = Oslo Health Study, TOP = Thematically Organized Psychosis study.

levels. The level of 25-hydroxyvitamin D was particularly low in the immigrant group in the fall/winter months and was most pronounced in Asian and African immigrants (Figure 1).

Table 2 shows differences in 25-hydroxyvitamin D levels for both Norwegians and immigrants of Asian origin from the TOP sample compared to that found among the general population (HUBRO sample). Total levels of 25-hydroxyvitamin D were significantly lower among the TOP sample compared to the HUBRO sample ($P < .001$). We found significantly higher levels of 25-hydroxyvitamin D among the Norwegians in the HUBRO sample compared to that found among Norwegians in the TOP sample. This finding is stable even after controlling for sex. The only exception is similar 25-hydroxyvitamin D levels in Norwegian men from the TOP and HUBRO sample in the spring/summer months (TOP = 68 ± 22, HUBRO = 77 ± 25; $t_{291} = 1.923$, not significant). On the other hand, there were significantly higher levels of 25-hydroxyvitamin D among Asian immigrants from the TOP sample compared to Pakistani immigrants from the HUBRO sample. This was primarily because Asians from the TOP sample had higher levels of 25-hydroxyvitamin D in the spring/summer months than the Asian population in the HUBRO sample. The findings were similar for male (TOP = 38 ± 16, HUBRO = 28 ± 13; $t_{90} = -2.542$, $P < .05$) and female (TOP = 52 ± 10, HUBRO = 25 ± 16; $t_{52} = -6.974$, $P < 001$) participants.

Simple χ^2 analysis of 25-hydroxyvitamin D levels between healthy Asians from Turkey, Sri Lanka, Iran, Pakistan, and Vietnam from the Immigrant-HUBRO sample compared to immigrants from Asia in the TOP sample showed no significant differences in vitamin D levels between groups ($\chi^2_1 = 0.477$).

Table 3 shows results from linear multiple regression for both samples (TOP and HUBRO). Among the TOP sample, we found that immigrant status and season of blood sampling explained 33% ($R^2 = 0.328$) of variance in serum levels of 25-hydroxyvitamin D ($F_{4,128} = 15.628$, $P < .001$), while age and sex did not contribute significantly to this model. The independent variables of GAF score means, years of education, dietary and exercise habits, and BMI were not included after observation of nonsignificant associations with vitamin D levels through bivariate analyses. Similar results were found in the HUBRO sample, with country of birth and season of blood sample explaining nearly 42% of the variance found in 25-hydroxyvitamin D levels ($R^2 = 0.420$; $F_{4,1041} = 188.088$, $P < .001$). Neither sex nor age contributed significantly to the model for the HUBRO sample either.

Finally, we examined bivariate correlations between 25-hydroxyvitamin D levels and PANSS, IDS-C, and YMRS scores for participants with psychosis (TOP sample). Table 4 shows only items with statistically significant correlations. Serum levels of 25-hydroxyvitamin D correlated negatively with present clinical symptoms of passive/apathetic social withdrawal and disorientation from the PANSS scale and with psychomotor retardation, somatic complaints, and lack of physical energy and positively with weight loss from the IDS-C scale. All of these items, excluding weight loss, correlated significantly with each other.

Correlations remained significant after controlling for impact of free thyroxin and TSH levels. After controlling for current major depression, the items of disorientation, weight loss, and lack of physical energy remained significantly correlated with 25-hydroxyvitamin D levels.

None of the items that measured symptoms of mania from the YMRS were found to correlate significantly with 25-hydroxyvitamin D levels.

DISCUSSION

The main finding of this study is that over 80% of the current sample of patients with psychosis from Oslo had

Table 4. Significant Bivariate and Partial Correlations Between Serum Levels of 25-Hydroxyvitamin D and Symptomatology Among Patients With Psychosis

Variable	Variance Explained, %	Vitamin D Level (n = 133)	Passive/Apathetic Social Withdrawal (n = 133)	Disorientation (n = 133)	Weight Loss (n = 89)	Psychomotor Activity Retardation (n = 93)	Somatic Complaint (n = 93)	Physical Energy (n = 93)
Bivariate *r* for vitamin D								
Vitamin D level		1.00	–0.19*	–0.22*	0.30***	–0.24*	–0.29**	–0.27**
Passive/apathetic social withdrawal[a]	3.5		1.00	0.25***	0.10	0.45****	0.21*	0.38****
Disorientation[a]	5			1.00	0.03	0.43****	0.45****	0.34***
Weight loss[b]	9				1.00	0.08	–0.07	0.00
Psychomotor activity retardation[b]	5.5					1.00	0.41****	0.60****
Somatic complaint[b]	8						1.00	0.63****
Physical energy[b]	7.5							1.00
Partial *r* after controlling for								
Current major depression (n = 38)[c]			–0.10	–0.35	0.35*	–0.30	–0.19	–0.33*
Free thyroxin (n = 85)			–0.14	–0.24*	0.30***	–0.22*	–0.29**	–0.27*
TSH (n = 85)			–0.12	–0.25*	0.29***	–0.20	–0.30***	–0.25*

*$P < .05$.
**$P < .01$.
***$P < .005$.
****$P < .001$.
[a]Items from Positive and Negative Syndrome Scale.
[b]Items from Inventory of Depressive Symptomatology–Clinician Rated.
[c]Structured Clinical Interview for *DSM-IV* Axis I disorders criteria.
Abbreviation: TSH = thyroid-stimulating hormone.

low serum levels of 25-hydroxyvitamin D, with almost 43% meeting criteria for vitamin D deficiency. In the spring/summer months, over 50% of patients had low serum levels of 25-hydroxyvitamin D (8% with deficiency). Among these patients with psychosis, immigrants had 25-hydroxyvitamin D deficiency significantly more often than Norwegians, independent of season. Patients with psychosis also had significantly lower 25-hydroxyvitamin D levels than the general population (HUBRO). This is primarily due to lower levels among Norwegian patients with psychosis. In addition, among the patients with psychosis, 25-hydroxyvitamin D was correlated to certain somatic symptoms associated with depression, as well as passive/apathetic social withdrawal and disorientation.

The current findings support earlier reports of the presence of vitamin D deficiency in patients with schizophrenia[7] and patients with other psychiatric illness.[10] However, our study is the first to show that this deficiency is higher among immigrants with psychosis than nonimmigrants. This supports Dealbarto's[13] hypothesis indicating that vitamin D deficiency may partially explain heightened risk of schizophrenia among immigrants moving from equatorial regions to northern hemispheres, but due to the current cross-sectional study design, we cannot provide evidence for causal relationship. Our results indicate a gradient of vitamin D deficiency in schizophrenia, with lowest levels of deficiency among the white sample, medium levels among the Asian sample, and highest among the sample from the African continent. A similar gradient is found in psychosis incidence, where results from the Aesop study in Great Britain suggest that the incidence of psychosis is heightened among all ethnic groups other than white British, but highest for the black populations from the Caribbean and Africa.[23] The underlying mechanisms are not known, but recent evidence indicates several other effects of vitamin D than only bone metabolism,[6] and both animal and human studies support an effect of vitamin D on brain functions.[24,25]

Even though Asians from both samples showed mean 25-hydroxyvitamin D levels beneath that deemed sufficient, we found higher vitamin D levels among Asians with psychosis than among Pakistanis from the general population, primarily in the spring/summer months. This finding was somewhat surprising but could be caused by differences between the comparison groups, as the HUBRO sample was all first-generation immigrants born in Pakistan, while the TOP sample was comprised of both first- as well as second-generation immigrants from all Asian countries. However, we did not find significant differences in percentage of subjects with vitamin D deficiency between Asians in the TOP sample compared to the Immigrant-HUBRO sample either.[3] Results may be limited by drop-out rates from the Oslo Health Study, but comprehensive analysis of nonattendance to HUBRO[26] and Immigrant-HUBRO[27] concluded that prevalence estimates were robust.

In the TOP study, none of the African immigrants with psychosis diagnosis had sufficient levels of 25-hydroxyvitamin D independent of which season the blood sample was drawn. We did not find any reports of vitamin D levels among African immigrants residing in Norway that could be compared with our result in the HUBRO study or elsewhere. It has been proposed that skin pigmentation and latitude are significant determinants in the cutaneous production of previtamin D_3[28] and that those with deeply pigmented skin require longer sun exposure to produce adequate vitamin D levels.[29] Also, skin cancer research in

Norway refers to findings that black Africans need 6 times more sun radiance to produce a certain amount of vitamin D than white Europeans,[30] and this may explain our current findings.

Clinical Implications

Our results have important clinical implications as they indicate that patients with psychotic disorders (at least within the schizophrenia spectrum) have a high degree of vitamin D deficiency, which is found to be associated with certain depressive and negative symptoms. Serum levels of vitamin D correlated with a possible somatic factor within the group of patients with psychosis and support earlier findings of an association between 25-hydroxyvitamin D deficiency and low mood.[31] Vitamin D dietary supplementation has been linked to mood as it has been found to significantly enhance positive affect and reduce negative affect in patients with seasonal affective disorder.[32] Also, our results concerning a relationship between vitamin D and weight loss and lack of energy, both somatic symptoms associated with depression, could be in line with recent findings indicating that calcium and vitamin D are important in weight regulation,[33] especially among those suffering from obesity.[34] These findings implicate that more regular vitamin D screening with following treatment regimens might improve the general health of this vulnerable patient population.

Limitations

The present study had several limitations. One could argue that vitamin D deficiency among patients with psychosis may not be directly associated with mental health but related to dietary habits or other health consequences associated with having a severe mental illness. As the present study was not designed to explore this explanation, no conclusions can be made regarding this question. However, based on the TOP dataset, we did not find indications that BMI, dietary habits, or physical fitness could explain 25-hydroxyvitamin D levels. Symptom severity or its association with the patients' function (GAF scores) could not explain the levels either. There may be a possible selection bias in the TOP sample as participants to this study were all clinical referrals and not based on an epidemiologic sample. How this could influence the results is unclear. More important, the study did not include objective measures of skin pigmentation or record dietary supplements, and further studies would benefit from inclusion of these measures. Finally, since the participants resided in Oslo, Norway, findings may not be generalizable to other populations.

CONCLUSION

Patients suffering from psychotic disorders in Norway, primarily within the schizophrenia category, have a high degree of vitamin D deficiency, most pronounced among immigrants. The relative decrease compared to nonpsychotic reference population was present in Norwegians only. Low vitamin D levels were found to be associated with certain somatic symptoms as well as passive/apathetic social withdrawal and disorientation among this patient group. These findings suggest that vitamin D could be involved in the underlying mechanisms related to psychosis and strongly suggest that more attention should be paid to identification of vitamin D deficiency in this particular group, since proper treatment could result in large health benefits.

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