Mood and Lithium in Drinking Water

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• To assess the possible relationship of lithium in the drinking water to some aspects of mental health, drinking water samples were collected from the homes of 384 individuals in Washington County, Md, who had been randomly selected for interview in a community mental health assessment program. The water was analyzed for lithium by atomic absorption spectrophotometry without knowledge of the interview results. The questionnaire contained the Lubin depression adjective check list, Center for Epidemiologic Studies depression and functioning scales, a general happiness question (Gurin), an aggression scale, and the Cantril ladder for self-rating of present status. In an area with low-to-moderate levels of lithium in the drinking water, there was no evidence to confirm earlier suggestions that the presence of lithium might be beneficial.

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Lithium salts have been used in the treatment of mental illness since Cade discovered their effect on psychotic excitement in 1949.[1] Since that time, numerous studies have established the effectiveness of the lithium ion on the manic phase of manic-depressive illness.[2-7] Its role in the depressive phase of manic-depression or recurrent depression is still controversial.

An effect on the normal mind has not been extensively studied. Schou has stated that it has no influence on the normal mind and does not smooth normal emotions.[8] Therapeutic doses to normal subjects have resulted in some feelings of indifference and passivity, but have had no effect on thought processes.[3]

The difference between doses of lithium used in medical practice and levels found in natural sources is tremendous. A commonly prescribed daily maintenance dose is 900 mg of lithium carbonate, corresponding to 170 mg of lithium per day. In contrast, environmental levels of lithium are measured in parts per billion.

The first suggestion that low environmental levels might exert an important effect on human health was the report by Dawson et al that admission rates to state mental hospitals in Texas were correlated inversely with the lithium concentration in drinking water sources.[9] Lithium levels ranged from 0 to 160 parts per billion (ppb). The association was found with total admissions and with the individual diagnostic categories of psychosis, neurosis, and personality disorder. A similar study was conducted by Voors in North Carolina.[10] He found trends in the same direction as Dawson et al. Higher lithium levels in water were associated with lower admission rates. Although only the category of neurosis yielded a statistically significant result, the results were interpreted as providing support for the Texas findings.

The preceding studies looked at the associations of lithium and mental illness on the basis of broad geographic associations, making it difficult to control for socioeconomic factors that might also be related to admissions to state institutions. The present study was undertaken to see if the levels of lithium in drinking water at home could be related to mood, as measured by a standardized psycho-social questionnaire with due allowance for the possible effects of a number of demographic and socioeconomic characteristics.

MATERIALS AND METHODS

Washington County is located in western Maryland. The Potomac River forms its southern boundary, the Blue Ridge Mountains its eastern border, and one of the valleys in the Allegheny Mountains its western edge. Most of the county lies in a broad limestone valley.

The Community Mental Health Epidemiology Program was conducted in Washington County by the Johns Hopkins

Training Center for Public Health Research and the Center for Epidemiologic Studies (CES), National Institute of Mental Health. A random sample of households was chosen each week, and a random adult individual from each household was then selected to be interviewed. The interview yielded information on demographic and socioeconomic variables, physical health, and mental health status. Mental status, particularly depressed mood, was measured as the scores of a series of scales adapted or developed for the program.

A drinking water sample from the tap was obtained from every rural or small-town resident interviewed between January 1972 and February 1973, and from a systematic sample of one of every three of the urban residents interviewed between August 1972 and February 1973. This distribution was used in order to obtain as many high lithium samples as possible, because a previous study indicated that city water uniformly had little lithium present, and that the highest levels were in some rural areas. Samples were collected by the interviewer into low-density polyethylene bottles.

Analyses were done on samples identified by code number only, and therefore, without knowledge of the source of the samples or of responses to the interview. Lithium was measured on an atomic absorption spectrophotometer after acidification of the samples with 70% to 72% perchloric acid at 5 ml/liter. Standards were prepared at lithium concentrations of 2, 10, 25, and 50 parts per billion, and a set of standards was analyzed before each group of approximately 12 samples.

Data compiled for each individual from the interview information included age, sex, race, education, income, marital status, occupational status, frequency of church attendance, number of years in the present residence, the water source of the residence, and the enumeration district of residence. Scores from the following scales were also obtained: CES depression, Lubin depression adjective check list, general happiness, aggression, CES-functioning, Cantril ladder of present status, and weighted life events.

The CES-depression and functioning scales were devised by the Center for Epidemiologic Studies. They were compiled from a number of previously established mental health status rating scales.[11] The aggression scale was also developed by the CES. The general happiness question is Gurin's Measure of Overall Happiness, which gave meaningful results in a nationwide mental health survey conducted by Gurin et al.[12] The Lubin depression adjective check list (DACL) used has been shown to differentiate depressed from non-depressed individuals.[13] Cantril devised the self-rating scale and tested it on a variety of populations.[14] The weighted life events scale was developed by Holmes and Rahe,[15] with the weights assigned on the basis of assessments by groups of individuals of the relative adjustment necessary for the various events. The relative ranking has been shown to be consistent in a number of population subgroups.[16]

The CES-depression and Lubin scales are used to indicate depressed mood. The happiness question is scored to measure expressed unhappiness, and hence will be called an unhappiness scale in this article. The Cantril ladder gives an indication of how an individual evaluates his present life situation. The functioning scale is an indicator of relative performance in normal activities. The aggressive scale give an indication of outward aggression. In its present form, the questionnaire has been validated on a group of psychiatric patients. There is a high degree of correlation between ratings of depression from the questionnaire and from observers.

In all cases, the scales are scored so that higher numerical scores are in the direction of depression or a high level of symptom reporting. To adjust for the effects of other variables, a binary variable multiple regression model, as described by Feldstein,[17] was used. This model assumes that the effects of the independent variables are additive; it does not assume linearity.

Independent variables included in the regression equation were the lithium level, age, sex, education, income, marital status, occupational status, weighted life events, and frequency of church attendance. These factors were chosen because they had previously been shown to correlate with the scores of the psycho-social scales. The dependent variables were the CES-depression (CES-D) scale, the unhappiness scale, the aggression scale, the Lubin depression adjective check list, the CES-functioning scale, and the Cantril ladder of present status. The independent variables were categorized. Lithium concentrations in the drinking water were grouped a 0 to 1.9, 2.0 to 5.9, and 6.0 and more parts per billion (Table 1); the other independent variables were grouped as shown in Table 2. The dependent variables were expressed as percent with high scores, namely those values representing the approximate upper quintile of the population. Significance testing used F-ratios, taking the trends with increasing lithium concentrations into account.

Table 1.—Frequency Distribution of Lithium in Drinking Water in 384 Samples

Lithium (ppb)	No. of Samples	(%)	Cumulative %
0-1.9	144	37.5	37.5
2.0-5.9	145	37.7	75.2
6.0-9.9	55	14.3	89.5
10.0-19.9	25	6.5	96.0
20.0-29.9	12	3.2	99.2
30.0+	3	0.8	100.0
Total	**384**	**100.0**	

RESULTS

The total sample consisted of 384 individuals. The concentration of lithium in the drinking water ranged from "not detectable" to 32 ppb. The distribution is skewed toward the low concentrations, with 38% below the limit of detection, and 10% above 10 ppb. The distribution of lithium levels is present in Table 1.

Lithium levels varied by type of water source. The highest lithium levels were found in deep wells. Two thirds of the samples with concentrations greater than or equal to 10 ppb were found in deep wells, and 24% of the deep wells had concentrations greater than or equal to 10 ppb. City waters had no levels greater than 12 ppb, and less than 2% had levels over 10 ppb.

The distribution of some demographic characteristics of the sample is shown in Table 2. The income was unknown for almost 9% of the sample. Therefore, the unknown category for this variable was included in all analyses. One individual was unknown for education and was arbitrarily placed in the completed-high-school category. There were no unknowns for the other variables.

Crude and adjusted proportions of persons with high scores for each psycho-social variable are presented in Table 3 by level of lithium in the drinking water. For one of the scales,

the CES-D, there is a slight tendency for the proportion of persons with high scores to increase with increasing lithium. For the Cantril ladder, there is a slight trend in the opposite direction, ie, higher lithium is associated with a lower percentage having scores above cut off. A higher numerical score is always associated with more depression or more symptom reporting. None of the associations for the total sample were statistically significant. Similar trends were noted between lithium levels and adjusted mean scores.

Because housewives and retired women are likely to spend much of their time at home and are thus exposed to home drinking water more than employed persons and students, the analysis was repeated for the 131 women in these two categories. The findings, shown in the second part of Table 3, were essentially the same as for the total group, except that the association of high CES-D scores with high lithium levels was more marked, and was statistically significant ($P < .01$).

COMMENT

With only one of six psycho-social scale scores showing even a slight association with lithium levels, the findings of this study lend little support to the possibility that low-to-moderate levels of lithium in drinking water have a demonstrable effect on depressed mood or feeling. The single important findings was in the opposite direction to that expected from the reports by Dawson et al and by Voors.[9,10] Their studies suggested that lithium could prevent some forms of mental illness.

The contradictory results of the present study may have resulted from a number of factors. The use of state mental hospital admission rates by Dawson et al and Voors as outcomes can be criticized because of possible bias. The geographic distribution of these rates might be explained on the basis of the location of these and other facilities; ie, these hospitals may be most available to the population in low lithium areas. Also, there may be additional selection of the population with respect to those

Table 2.—Demographic Characteristics of the Sample

Characteristics	No. of Persons (%)
Age	
18-24	46 (12.0)
25-44	140 (36.4)
45-64	144 (37.5)
65 and over	54 (14.1)
Sex	
Male	164 (42.7)
Female	220 (57.3)
Education	
More than high school	79 (20.6)
High school	120 (31.2)
Less than high school	185 (48.2)
Income (yearly)	
Less than $4,000	71 (18.5)
$4,000-$7,999	68 (17.7)
$8,000-$15,999	165 (43.0)
$16,000 or more	47 (12.2)
Unknown	33 (8.6)
Marital status	
Never married	34 (8.8)
Currently married	291 (75.8)
Ever married	59 (15.4)
Occupational status	
Employed	216 (56.2)
Housewife	107 (27.9)
Unemployed	9 (2.3)
Other (retired, student, etc)	52 (13.5)
Weighted life events score	
0-159	316 (82.3)
160-309	59 (15.4)
310 and over	9 (2.3)
Church attendance	
Less than twice a year	121 (31.5)
Between twice a year and once a week	121 (31.5)
At least once a week	142 (37.0)

Table 3.—Percentages of Persons With High Scores on Several Instruments*

Instrument	Crude Rates (%) Lithium (ppb)			Adjusted Rates (%) Lithium (ppb)		
	0-1.9	2.0-5.9	6.0+	0-1.9	2.0-5.9	6.0+
Total Study Population (384 individuals)						
CES-D	13.9	15.9	20.0	14.2	15.1	20.7
Lubin DACL	25.2	28.3	26.6	24.5	28.3	27.5
Cantril ladder, present	26.1	23.6	23.1	25.6	24.2	23.0
Unhappiness	4.9	9.0	6.3	4.6	9.0	6.6
Dysfunctioning	19.4	18.6	18.9	19.1	19.5	18.2
Aggression	15.3	14.5	13.7	15.0	13.8	15.3
Housewives and Retired Women (131 individuals)						
CES-D	11.1	14.3	43.3	10.7	15.0	42.6†
Lubin DACL	22.7	25.0	30.0	23.5	23.8	31.0
Cantril ladder, present	20.5	27.3	17.9	20.5	27.6	17.1
Unhappiness	6.7	8.9	6.7	3.4	11.4	7.0
Dysfunctioning	33.3	17.9	23.3	27.8	21.2	25.4
Aggression	8.9	14.3	16.7	12.7	11.5	16.1

* Crude and adjusted percentages of persons with high scores on several instruments for assessing mood by lithium concentration (parts per billion) in drinking water in the home. Rates are adjusted for the effects of age, sex, marital status, education, income, occupation, weighted life events score, and frequency of church attendance.

† $P < .01$.

who go to a state hospital and those who attend some other type of facility.

On the other hand, the scales used in the present study do not measure mental illness per se, but give indications of general mood, quite likely often within the normal range of emotions. The relationship of lithium, if any, to a normal mind fluctuating over a normal range may not be the same as the relationship with more definite illness.[3]

The range of values of lithium seen in the present study is not as broad as that seen by Dawson et al, who measured up to 160 ppb, or Voors, who recorded a few levels as high as 95 ppb. The narrower range in Washington County may have been a handicap in observing relationships. However, the direction of the observed trends gave no indication that a broader range of values would have shown a significantly inverse relationship.

The associations of mood scores with lithium levels in this study cannot be differentiated from associations with place of residence, because all of the high lithium levels were found in rural areas, while drinking water in urban areas had no lithium. However, among 1,631 persons interviewed during the same time period with the same questionnaire, mean depression scores obtained from the CES-D instrument were slightly lower for rural areas than for the rest of the county. Thus, it seems unlikely that rural residence per se was a confounding factor that could account for our findings.

Despite the problems of comparability, our study can in no way be construed as supporting the hypotheses of the previous investigators. If there is an effect of lithium in drinking water, it does not appear to be beneficial at these levels, at least for these measures of mental health. One would therefore hesitate to advocate adding lithium to the water as has been previously suggested.[10]

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