Drinking Water
Lithium and Mental Hospital Admissions

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Introduction

In December 1970, Dawson, Moore, and McGanity[1] published a paper in which they reported a significant relationship between the lithium concentration in the drinking waters of 27 counties in Texas and the incidence of first admissions and readmissions to Texas State Mental Hospitals. They speculate that "naturally occurring lithium exerts a measurable and statistically significant influence on the incidence of patients admitted to our State Mental Hospitals and on certain categories of mental illness". The categories whose admissions they reported as influenced by lithium levels were psychoses, neuroses, and personality disorders. The present report gives a simpler alternative explanation of the observed findings. It is our conclusion that no direct or causative relationship exists between drinking water lithium and mental hospital admissions.

Background

Cade introduced lithium salts as pharmacologically effective agents in treatment of affective psychoses in 1949; he also proposed that effects of water in certain medicinal springs might be due to the lithium content[2]. Since that time and particularly since lithium came into widespread use during the past decade, interest in possible healing or prophylactic effects of naturally-occurring lithium has grown, possibly because the active agent is the lithium ion itself —it is not metabolized in the organism.[3]

Blachly[4] demonstrated a significant negative correlation (r=-0.3989) between lithium content of drinking water and death rates from arteriosclerotic heart disease in white males age 45-54 in the major cities of the U.S. Blachly emphasizes that the concentration of lithium in drinking water is exceedingly low (median 2.0 ppb), and that correlation is not causation. Steinberg and Rosin[2] also stress that, since ab-

solute lithium concentrations in drinking water are very small, it is unlikely that this exerts any significant psychopharmacological effect. In spite of this caution Voors[5] suggests adding more lithium to municipal water supplies of the statistically noted inverse relationship to arteriosclerotic heart disease.

Dawson and associates[1] turned their attention to possible relationships between drinking water lithium and mental hospital admissions. They used information about lithium content in municipal tap water from 26 counties of Texas which had been obtained in the course of a nutrition survey. They later added Galveston County to make a total of 27 communities. They then studied these lithium values in relation to admissions plus readmissions to the nine Texas State Mental Hospitals, as provided in published data books[6,7], using only those three categories of illness (psychosis, neurosis, and personality disorder) which appeared "in sufficient numbers to warrant inclusion". In passing, they brought out that lithium levels were very significantly inversely related to annual rainfall. By grouping their 27 counties into 4 groups according to lithium level, and by converting hospital admissions for the 3 categories of illness into rates, they showed a highly significant difference in the mean admission rate for the 4 groups of communities; in all cases, those with high lithium levels had the lowest admission rates. Dawson and associates acknowledge that they have no data on admissions to private, municipal, and federal institutions, and that proximity of residence to one of the nine state hospitals may also have influenced admissions. They also mention the extremely minute amounts of lithium in drinking water as compared to the doses necessary in treatment of mental illness. Nevertheless, they conclude that naturally occurring lithium exerts an influence on the incidence of state mental hospital admissions.

This message has been repeated and magnified in secondary reports[8,9]. In press releases Dawson[10] is reported as saying that lithium in drinking water "appears to protect against some forms of mental illness as fluoride protects against tooth decay".

Dawson and associates have certainly identified a significant mathematical relationship. It is difficult to accept that this is a causal relationship, for these reasons (some mentioned earlier):

1. The amounts of lithium in drinking water are exceedingly small. Even in Dawson's county (Duval) with the highest level, this is only 160 μg/liter. If a person drank two liters of such water daily he would ingest 320 μg, or 0.3 mg daily, but the amount of lithium carbonate necessary to build up and maintain a therapeutic blood level is in the range of 600 to 1800 μg daily.[3]

2. The categories of illness on which lithium is reported to exert some effect, namely, psychoses, neuroses, and personality disorders, do not present a good fit to what is known about lithium, namely, that it is most effective in manic illness, perhaps in depressive illness, but has no consistently reported effect on anxiety, behavior disorders, thought disorder, etc.

Dawson's Table 1 brings out clearly that the high lithium counties are mainly from the Rio Grande River Valley. None of the counties in the other three groups is from the Rio Grande River area. For those familiar with Texas geography and population distribution, several possibly relevant consequences of this will suggest themselves:

1. The Rio Grande River forms 889 miles of the border of Texas[11]. This is in general a sparsely populated area.

2. The 9 State Hospitals have mostly been built in the populous and longer-settled Eastern and Central parts of the state.

3. State Hospitals tend to be located more centrally, and away from the border. The state hospitals which serve most of the Rio Grande area counties (Big Spring, Austin, and San Antonio State Hospitals) are all located 150 to 300 miles away.

4. The ethnic distribution of the Texas population is far from uniform: there are far more Texans of Mexican descent along the Rio Grande border; there are far more blacks and whites of Anglo-Saxon descent in East Texas; descendants of more recent European immigrants tend to be concentrated in the center.

These facts suggest an alternate hypothesis, that Dawson and associates are picking up the effects of geographic proximity of residence on mental hospital admissions, and that this is related to lithium levels by chance because of the particular geography of Texas. It is a well established fact that accessibility has a strong bearing on the use of public mental hospitals; this is called "Jarvis' Law"[12,13,14], having been first reported by a Dr. E. Jarvis of the Worcester (Massachusetts) State Hospital before the Civil War. This phenomenon has been widely confirmed in the U.S. and Europe[13]. The marked influence of distance to the state hospital on rate of first admissions has been found to apply to all age groups, to non-whites and whites, and to the functional psychoses as well as to milder disorders; it was not an artifact due to the effects of poverty or urbanization[13].

To test the hypothesis that Dawson's findings simply represent the workings of Jarvis' law, we have done computations with Dawson's data from 27 counties taking distance from hospital into consideration. We have also done this with data from all of the 254 counties of the State.

Procedure

For mental hospital admissions, we used the same time period as Dawson and associates (Sept 1, 1967 through Aug 31, 1969), and used first admission plus readmission figures for the individual counties from the same data books[6,7]. In the case of the "Personality Disorder" group, however, the groupings in the two data books were not strictly comparable, and for this reason we went back to the original data to make the 1968 grouping conform to that of 1969.

We decided against converting numbers of admissions to rates because this equalizes the statistical weight of counties, even though they have populations ranging from a few hundred to more than a million. Instead, we recorded actual numbers of admissions and also county population, and later removed the strong effect of differing populations by partial correlations.

For values for lithium level in drinking water, we used the values published in the last column of Table 1 of Dawson and associates[1] for the 27 counties there named. For the remaining 227 counties, we estimated the lithium level from Dawson's Fig. 1 and Fig. 2, which gives bands of average annual rainfall superimposed on a map of the State, together with the mean municipal water lithium levels for each rainfall level band. Wherever a county fell on the border of two rainfall bands, it was assigned to that band including the larger portion of the county.

The statistical technique used was partial correlation, a technique that nullifies the effect of a third variable or several other variables upon both of the variables being correlated[15]. Principally we studied the correlations between lithium levels and number of mental hospital admissions after removing the influence of county population and distance from the county seat to the nearest state mental hospital.

For diagnostic groupings, we used the same 3 groups reported by Dawson et al. (total Psychoses, Neuroses, and Personality Disorders). In addition, for the state as a whole, we also studied Schizophrenics, Psychotic Organic Brain Snydromes, other Psychotics (which would include Affective Disorders), and total admissions.

Results:

The correlations between population, lithium levels, distance to state mental hospital, and admissions of the 3 diagnostic categories reported by Dawson et al.[1] are given in Table 1, for Dawson's 27 counties, and in Table 2 for all 254 counties of the state.

It is obvious that there is a very high positive correlation between population of the county and number of admissions, as one would expect. When the effect of population is removed by partial correlation, there remain negative correlations between hospital admissions and lithium levels: for Dawson's 27 counties, these are −0.13 for total Psychoses, −0.18 for Neuroses, and −0.21 for Personality Disorders; for all 254 counties, these are −0.10 for total Psychoses, −0.11 for Neuroses, and −0.05 for Personality Disorders.

If we look at the correlations between distance from State Hospital and number of admissions, removing the effect of population by partial correlation, the results are more impressive: for Dawson's 27 counties, the resulting correlations are −0.32 for total Psychoses, −0.32 for Neuroses, and −0.37 for Personality Disorders; for all 254 counties, the corresponding correlations were −0.19, −0.17, and −0.13.

By second order partial correlation, we then removed the influence of both county population and distance to state mental hospital. The resulting correlations between lithium levels and numbers of admissions were all small and non-significant: for Dawson's 27 counties, the

TABLE 1
Correlations between Population, Lithium, Distance to Hospital, and Admissions for 27 Counties

	a	b	c	d	e	f
a. 1970 Population	1.00					
b. Lithium levels in drinking water	− .21	1.00				
c. Miles to State Mental Hospital	− .28	.44	1.00			
d. Admissions, Total Psychoses	.94	− .24	− .37	1.00		
e. Admissions, Neuroses	.93	− .26	− .37	.99	1.00	
f. Admissions, Personality Disorders	.91	− .27	− .39	.98	.98	1.00

TABLE 2
Correlations between Population, Lithium, Distance to Hospital, and Admissions for 254 Counties

	a	b	c	d	e	f
a. 1970 Population	1.00					
b. Lithium levels in drinking water	− .19	1.00				
c. Miles to State Mental Hospital	− .15	.43	1.00			
d. Admissions, Total Psychoses	.95	− .21	− .20	1.00		
e. Admissions, Neuroses	.92	− .22	− .21	.97	1.00	
f. Admissions, Personality Disorders	.92	− .20	− .19	.98	.96	1.00

correlation between lithium level and admission for total Psychoses was 0.00, for Neuroses –0.05, and for Personality Disorders –0.08; for all 254 counties, the corresponding correlation coefficients were –0.02, –0.05, and 0.00. Finally, for all 254 counties, the correlations between lithium levels and admissions, after partialling out effects of county population and distance to mental hospital for other patient groupings were as follows: total admissions, –0.04; Schizophrenia, –0.01; Psychotic Organic Brain Syndrome, –0.06; and other Psychotics (this includes Affective Disorders), –0.06. These are not statistically significant correlations.

Discussion:

We feel that Jarvis' Law, which says that admissions to state mental hospitals vary positively with accessibility (geographic proximity), is the simplest and most plausible explanation for the findings of Dawson and associates concerning Texas State Mental Hospital admissions. The fact that a statistical relationship to lithium levels of municipal drinking water supplies is picked up is in our opinion due to quirks of Texas geography and history, resulting in having most of the population concentrations and most of the state mental hospitals at some distance from the relatively high-lithium Rio Grande border.

Until there is more convincing evidence that the minute amounts of lithium in drinking water exert any influence on the incidence of mental illness, we consider discussions of the "protective" effect of naturally-occurring lithium to be premature.

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