

## A Quantitative Assessment of Sleep Laboratory Activity in the United States

Naoko Tachibana M.D.<sup>3</sup>; Najib T. Ayas M.D.<sup>1,2</sup>; David P. White M.D.<sup>1,2</sup>

<sup>1</sup>Division of Sleep Medicine, Department of Medicine, Brigham and Women's Hospital and <sup>2</sup>Harvard Medical School, Boston MA; <sup>3</sup>Osaka Medical Center for Health Science and Promotion, Japan

**Study Objectives:** To determine the total number of active sleep laboratories in the United States and the number of polysomnograms conducted on a yearly basis in these laboratories.

**Methods:** All members of the AASM and all AASM accredited sleep laboratory directors received a questionnaire addressing their laboratory and its volume. In three states, multiple telephone calls to AASM members were used to correctly identify the absolute number of labs and their PSG volume in those states. Extrapolating from the number of labs studies identified per questionnaire relative to the correct number (per calls) in those states and, then applying this ratio to the entire US, the total number of labs and studies was determined.

**Results:** Our data suggests that there are, in the year 2001, 1,292 sleep

laboratories conducting 1,165,135 polysomnograms per year. This comes to 427 PSG's/year per 100,000 population in the United States.

**Conclusions:** These data suggest that there are a relatively large number of sleep laboratories in the US conducting a substantial number of PSG's. However, there was considerable variability in this volume between states that did not relate to known markers of healthcare utilization. These numbers have likely increased since 2001.

**Key Words:** Sleep laboratories, polysomnograms, United States.

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Over the last 20 to 25 years, the use of clinical sleep laboratories to diagnose and treat a variety of sleep-related conditions has increased dramatically. Most such activity has evolved around the recognition of obstructive sleep apnea as a common disorder with important adverse neurocognitive and cardiovascular outcomes.<sup>1,2</sup> The diagnosis of sleep apnea and the initiation of therapy are most commonly accomplished in the sleep laboratory with overnight polysomnography. Despite the apparent increase in sleep laboratory activity, there has been no quantitative assessment of the number of sleep studies conducted in the United States. We sought to determine the number of sleep laboratories and sleep studies conducted in the United States at the current time, and, to some extent, to assess variability in sleep testing in different areas/states within the United States (U.S.). In this project, we did not address the number of ambulatory or home studies.

### METHODS

To estimate the number of sleep laboratories and overnight sleep studies performed per year in the United States, we first mailed a brief questionnaire to all American Academy of Sleep Medicine (AASM) accredited sleep centers in the U.S., excluding Puerto Rico, and all individual members of the AASM. This questionnaire was mailed in March 2001 with all utilized

responses received by June 1, 2001.

We then selected three states in which to undertake a more precise assessment of the number of laboratories/sleep studies performed (Massachusetts, Oregon, and Louisiana). We selected these states because they are approximately equal in population, but represent a diversity of socioeconomic status and geography. To more precisely determine the number of sleep studies performed, we identified phone numbers and addresses of all known AASM members and sleep laboratories in these states (from AASM listings and telephone directories). We then contacted every AASM member (or accredited center) who did not respond to the original survey by telephone or by email to obtain information concerning the number of polysomnograms performed per week. We also asked about other laboratories in their area and contacted these physicians/clinicians as well.

Once we were confident that we knew precisely the number of sleep laboratories and polysomnograms conducted in these three states, we could then determine the percentage of laboratories/studies identified by the original survey: [actual number of sleep studies (or labs)/number from the original mail survey]. This ratio was then used to extrapolate the actual number of laboratories/studies conducted in the other 47 states.

The number of sleep studies per capita was calculated by dividing the number of sleep studies performed per year by the country's or state's population (from the U.S. Census year 1999).

### RESULTS

We sent surveys to 507 accredited sleep centers and 3,697 AASM members. A total of 725 surveys were returned. This represented information from 633 individual sleep centers (i.e. 92 were duplicate responses). The number of responses obtained from each state is shown in Table 1 (column 6). Overall, data were obtained from 262 AASM accredited sleep laboratories (52% response rate) and 371 non-AASM accredited laboratories.

### Disclosure Statement

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Address correspondence to: David P. White, M.D., Division of Sleep Medicine, Brigham and Women's Hospital, Sleep Research at B1, 75 Francis Street, Boston, MA 02115, Tel: (617) 732-5778, Fax: (617) 975-0809

**Table 1**—Number of PSG's Performed in the United States According to State

State (alphabetical)	Number of PSG/year Reported From Mail Survey	Total Estimated Number of PSG/year*	Population	Number of PSG/year/100 000 population**	Number of responding labs (mail survey)	Estimated Number of labs***
Alabama	18980	32646	4,369,862	747.1	16	33
Alaska	2288	3935	619,500	635.2	3	6
Arizona	8034	13818	4,778,332	289.2	6	12
Arkansas	6110	10509	2,551,373	411.9	8	16
California	39728	68332	33,145,121	206.2	44	90
Colorado	2860	4919	4,056,133	121.3	5	10
Connecticut	11596	19945	3,282,101	607.7	14	29
Delaware	1040	1789	753,538	237.4	1	2
District of Columbia	1768	3041	519,000	585.9	1	2
Florida	38272	65828	15,111,244	435.6	36	73
Georgia	31044	53396	7,788,240	685.6	21	43
Hawaii	2470	4248	1,185,497	358.4	3	6
Idaho	4368	7513	1,251,700	600.2	6	12
Illinois	32682	56213	12,128,370	463.5	30	61
Indiana	18512	31841	5,942,901	535.8	16	33
Iowa	6032	10375	2,869,413	361.6	10	20
Kansas	7930	13640	2,654,052	513.9	11	22
Kentucky	14820	25490	3,960,825	643.6	14	29
Louisiana	10322	17754	4,372,035	406.1	14	29
Maine	2912	5009	1,253,040	399.7	6	12
Maryland	34918	60059	5,171,634	1161.3	13	27
Massachusetts	19006	32690	6,175,169	529.4	17	34
Michigan	40560	69763	9,863,775	707.3	29	59
Minnesota	10400	17888	4,775,503	374.6	8	16
Mississippi	6604	11359	2,768,619	410.3	6	12
Missouri	12792	22002	5,468,338	402.4	10	20
Montana	2938	5053	882,779	572.4	5	10
Nebraska	4836	8318	1,666,028	499.3	5	10
Nevada	4576	7871	1,809,263	435.0	4	8
New Hampshire	5096	8765	1,201,134	729.7	6	12
New Jersey	13520	23254	8,143,412	285.6	13	27
New Mexico	4524	7781	1,739,844	447.2	4	8
New York	31720	54558	18,196,601	299.8	28	57
North Carolina	13962	24015	7,650,789	313.9	11	22
North Dakota	3432	5903	633,666	931.6	3	6
Ohio	34580	59478	11,256,654	528.4	30	61
Oklahoma	2782	4785	3,358,044	142.5	3	6
Oregon	8632	14847	3,316,154	447.7	10	20
Pennsylvania	33904	58315	11,994,016	486.2	33	67
Rhode Island	2808	4830	990,819	487.5	2	4
South Carolina	9464	16278	3,885,736	418.9	7	14
South Dakota	1456	2504	733,133	341.6	2	4
Tennessee	21658	37252	5,483,535	679.3	19	39
Texas	27560	47403	20,044,141	236.5	32	65
Utah	11180	19230	2,129,836	902.9	7	14
Vermont	624	1073	593,740	180.8	1	2
Virginia	16588	28531	6,872,912	415.1	18	37
Washington	15548	26743	5,756,361	464.6	14	29
West Virginia	5460	9391	1,806,298	519.9	7	14
Wisconsin	14092	24238	5,250,446	461.6	19	39
Wyoming	416	716	479,602	149.2	2	4
<i>Total</i>	<i>677404</i>	<i>1165135</i>	<i>272,690,258</i>	<i>427</i>	<i>633</i>	<i>1292</i>

\*For Louisiana, Oregon, and Massachusetts, this value was obtained through telephone/email contact with all known sleep laboratories. For the other states, this value was generated by multiplying the number of PSG's as reported from the mail survey by 1.72 (see text)

\*\* This value was calculated by dividing column three with column four

\*\*\* For Louisiana, Oregon, and Massachusetts, this value was obtained through telephone/email contact with all known sleep laboratories. For the other states, this value was generated by multiplying the number of laboratories that responded to the mail survey by 2.041 (see text)

## DISCUSSION

We were able to contact and obtain the needed information from all known sleep centers in Louisiana (29 laboratories), Oregon (20 laboratories), and Massachusetts (34 laboratories). Twenty-four (29%) of these sleep centers were accredited and 59 were not. Of these 83 laboratories, 41 of them responded to the original mailed survey (i.e. response rate=49%; ratio of number of actual/responder laboratories=2.041). The response rate of accredited laboratories (14/24, 58%) and non-accredited laboratories (27/59, 46%) were not significantly different ( $p=0.34$ , Fisher's exact test). Assuming a similar response rate from all the laboratories in America, we estimated that 1292 sleep centers are present in the United States (i.e.  $633 \times 2.041$ ). The number of sleep centers in each state (except LA, OR, and MA) was estimated in a similar manner (Table 1, column 7).

The number of sleep studies performed each year in each of the three index states was 18,580 (LA), 18,127 (OR), and 28,509 (MA). As expected, this number was greater than that reported from the returned mailed questionnaires (i.e. 10,322, 8,632, 19,006, respectively). The ratio of sleep studies determined from direct contact with the centers versus the mail survey was 1.72 when data from all three states were pooled together (ratios of 1.8, 2.1, and 1.5 for LA, OR, and MA respectively).

The reported number of yearly sleep studies performed in each state (solely from the mail survey) is shown in Table 1 (column 2). The number of studies determined from the in-depth analysis described above for Massachusetts, Oregon, and Louisiana is also shown in Table 1 (column 3) for those three states. For the other states, an estimate of the actual number of PSG conducted yearly was calculated by multiplying the number of studies reported by the mail survey by 1.72 (Table 1, column 3). Using this technique, the total number of PSG performed per year in America was 1.17 million or 427 per 100,000 population.

The per capita PSG rate varied tremendously between states (Table 1, column 4). The fewest number were performed in Colorado (121 PSG/year/100,000 people) and the most in Maryland (1116 PSG/year/100,000 people). We attempted to identify significant predictors of state PSG variability. Not surprisingly, there was a strong correlation between the per capita number of sleep laboratories and the per capita rate of PSG's (Spearman correlation coefficient=0.632,  $p<0.001$ ). There was a weak relationship between the state per capita rate of sleep studies and the per capita number of AASM members (Spearman=0.40,  $p=0.004$ ). However, the per capita rate of PSG in each state was not correlated with risk factors for OSA (mean age, percentage of males), suggesting that utilization was not distributed according to disease prevalence. Socioeconomic factors (poverty level and median income), Medicare reimbursement rates for PSG, percentage of uninsured, population density, race, and geographic location (West Coast, East Coast, Mid-West, South-West) were also not predictors.

The per capita number of sleep laboratories correlated with AASM member density (Spearman=0.32,  $p=0.02$ ) and weakly with the Medicare reimbursement rate (Spearman=-0.27,  $p=0.06$ ) but not with any other variables.

We asked the primary specialty of the director in all mail surveys in the United States (Table 2). The majority of sleep laboratories in the United States, both accredited and non-accredited, were directed by pulmonologists with the next most common specialty being Neurology.

This is the first study that has attempted to determine the annual number of sleep studies conducted in the United States. We found that in 2001, there were 1.17 million PSG's conducted over the last year (427 PSG's/100,000 population). There was substantial state to state variability ranging from 121 to 1161 studies/year/100 000 population.

We were also able to estimate the number of sleep laboratories in the United States (approximately 1292). In our three index states, only a minority (29%) of laboratories were accredited suggesting that the majority of sleep centers in America are not accredited by the AASM. The distribution of PSG utilization in the United States varied considerably between states. There was a weak association between the number of AASM members per capita and the rate of sleep studies performed, which may explain some of this variability. However, we were surprised that other variables known to be associated with utilization of healthcare resources were not.<sup>3,4,5</sup> In particular, socioeconomic status, geographic location, Medicare reimbursement rates, race, and distribution of OSA risk factors were not associated with the per capita rate of sleep studies. Thus, at the present time, the explanation for the varied distribution of sleep study utilization in America remains unclear.

We recognize that the accuracy of our estimates may have been compromised for a variety of reasons. First, we relied on self-reports to obtain information about the number of PSG conducted in each laboratory. The accuracy of such reports may have varied. However, we doubt there would be a consistent over or underestimation of the number of PSG's. Consequently, given the large number of responses obtained in our study, we doubt this substantially affected our results. Second, we may not have identified all sleep centers in the United States as we relied primarily on AASM lists. Some individuals running sleep laboratories may not be AASM members. This may have been particularly important in our three index states. Nevertheless, we doubt the number of overlooked labs was large or led to substantial underestimation of laboratories or studies. Third, we have assumed that the ratio of the actual number of sleep studies/laboratories divided by the number determined from the mail survey was the same in all states. Although some error in individual state estimates was almost certainly introduced by this assumption, we believe this to be a reasonable assumption as the ratio in

**Table 2**—Primary Specialty of the Sleep Laboratory Director

Primary Specialty	Accredited Center	Non-Accredited Center
Pulmonary	50.8%	54.2%
Neurology	16.4%	17.7%
Sleep Medicine	6.5%	7.0%
Psychology	6.5%	1.1%
Psychiatry	4.2%	1.9%
Pediatrics	2.7%	2.4%
Internal Medicine	1.9%	3.5%
Other specialty	2.7%	6.7%
Pulmonology and Neurology	3.4%	1.3%
Pulmonology and another specialty	3.1%	1.6%
Other combinations	1.5%	1.3%
No director	0%	1.1%
No answer	0.4%	0.3%

our three index states was relatively similar. We therefore believe our results to be a reasonably accurate representation of the rate of sleep studies performed in both countries.

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