

## Appendix II

### THEORETICAL CAPACITY AND ACTUAL OUTPUT OF A CT SCANNER

The theoretical capacity of a CT scanner is the number of scans that it can produce per time period and is a function of several variables. The most important variables are scanning speed (determined by machine design), hours of operation per day, and time spent per patient examination. Because all of these factors, except scanning speed, may vary during use, estimated theoretical capacity may differ from actual output. In particular, the number of hours per week considered full utilization has ranged from 40 or 50 to **80** hours.

Early calculations of capacity were based on the fact that head scans were scheduled at hour intervals. The Colorado Radiological Society made the lowest known estimate of operational capacity on this basis, **1,800 examinations** per year (**109**). This figure assumes 1 hour per scan, **40** hours per week, and allows for holidays and "downtime." Different manufacturers estimated different numbers of scans possible per 8-hour day in 1975 and 1976, with ranges from 10 to almost 30 per 8-hour day, or 2,600 to 7,800 examinations per year (assuming 260 days of operation per year). The Philadelphia Comprehensive Health Planning Agency estimated an operational capacity of 4000 examinations per year (assuming 16 patients per day) (**582**). Thus, theoretical capacity, assuming an hour per head scan, could range from below 2,000 examinations per year with a 40-hour week to about 4,000 examinations per year with an 80-hour week. One hour per head scan continues to be valid, as indicated by Evens and Jest (**158**), which found that head scans done on body scanners take an average of 32 minutes without contrast material and 53 minutes with contrast (presumably a noncontrasted scan followed by a contrasted scan).

Few data on actual operation levels of CT head scanners have been collected, and most surveys have been limited to older and slower machines. The following yearly numbers of examinations per machine (uncorrected for case mix) have been reported for **1975** and **1976**: Evens and Jest, **3,276 (29)**; Buenger and Huckman, **3,260 (264)**; Genessee Valley Health Planning Council, **3,000 (577)**; Health Planning Council of Rhode Island, **3,000 (584)**; Tri-State Area Health Planning Council, Inc., **2,900 (556)**; and Podell, **3,100 (425)**. Most machines in these surveys were available more than **8 hours a day, 5 to 5.4 days a week (29, 159, 440)**.

These results do not translate directly to CT body scanners. In 1977, Evens and Jest (**158**) found that an abdominal scan takes 50 minutes without contrast material and 77 minutes with contrast, and a pelvic scan takes 44 minutes without contrast material and 62 with contrast. Thus, if a body scanner performed only body scans and used contrast material on all examinations, and if one assumes that all scans were of the abdomen, the average time per scan would be 77 minutes. Operating **50** hours a week and 50 weeks a year, such a body scanner could perform about 2,000

contrasted abdominal scans per year. To achieve 2,500 scans would require operation for about 64 hours per week.

If a body scanner were used as the Evens and Jest survey of 1977 (158) indicates, performing 59 percent of its scans of the head and 41 percent of the rest of the body (mostly the abdomen), a scanner's theoretical capacity would be higher. The body scanners in the Evens and Jest survey operated an average of 46 hours per week (52 hours minus 6 hours "downtime"). Contrasted head scans required 53 minutes per scan and contrasted abdominal scans 77 minutes. If all scans were contrasted and the machine was operational 50 weeks a year, the theoretical capacity would be about 2,200 examinations per year. Since 68 percent of head scans and 65 percent of abdominal scans were contrasted, the capacity of a body scanner, operating the stated number of hours, would be higher, about 2,500 examinations per year. These calculations may underestimate the **capacity of a body scanner**, since they use the average time of abdominal examinations for the 41 percent of examinations other than the head. Abdominal examinations accounted for an average of only 29 percent of all examinations, but required the longest time per examination (158).

These theoretical calculations may be compared to actual experience. In a 1975 survey, Buenger (80) found that institutions performed scans an average of 12.5 hours per day. The American Hospital Association reported similar figures in its 1976 survey of 41 hospitals (29). In a 1976 survey Evens and Jest (159) found the average operating time of **98 machines was 11.8 hours per day**, and **90 of the 98 scanners** were available 24 hours a day for emergencies. These machines were primarily head scanners. In 1977, the Evens and Jest survey of body scanners found that the usual body scanner operated **5.2 days per week and 10 hours a day (158)**. However, only **32 patients** per week were examined on those body scanners. That number may be compared to the earlier Evens and Jest survey of primarily head scanners which found **58 patients** a week being examined (159).

Although downtime can reduce the level of output, it has not seriously limited CT scanners. Downtime is reported to average 2.4 to 7.0 hours a week and is expected to decrease as staff gain experience with CT scanners (82, 159).

The National Guidelines for Health Planning are based on a theoretical capacity of 2,500 examinations per year, regardless of type of examination (582). It appears from the 1977 Evens and Jest survey that many body scanners in this country will not reach the standard (158). One purpose of the Guidelines is to assure full utilization of existing scanners before allowing additional scanners in a particular area. The Guidelines do not take into account some of the complexities described above, but do allow adjustment of the standards by HSAs and State health planning agencies to allow for such factors.