Radiologist Productivity Increases With Real-Time Monitoring: The Hawthorne Effect

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DESCRIPTION OF THE PROBLEM

People produce more when they are monitored. This simple principle forms the basis of the Hawthorne Effect, historically described as the increase in human manufacturing productivity when it is formally observed and measured [1]. The Hawthorne Effect is based on research conducted during the 1920s, when Western Electric's Hawthorne Works in Cicero, Illinois, just outside of Chicago, began an 8-year project to study human factors that affect manufacturing productivity [1]. Researchers conducted "illuminating experiments," altering worker's lighting conditions while recording other factors, including temperature, humidity, and social interactions, to identify the conditions that affected productivity [2].

Their salient observation was that productivity increased regardless of the interventions, owing to simply the awareness by workers that they were being monitored [3]. The Hawthorne Effect is often cited in medical research as a confounding bias, because patients change their behavior when they know that they are being monitored in a study. Researchers often try to quantify the Hawthorne Effect to adjust research data outcomes [4,5]. In a 2008 *Radiology Business* article, Richard Duszak, MD, now Vice Chair for Health Policy and Practice, Department of Radiology, at Emory University School of Medicine, was quoted as saying: "Just knowing you're being measured can be all it takes to motivate you to change your behavior—the Hawthorne effect" [6].

The radiology group in private practice reviewed for this article included 6 full-time, partnered imaging radiologists who filled 88.9% of the weekday primary shifts during the 12 months of review, including the current first author. Historically, this practice employed 4.0 radiologists during the primary weekday shift, who read images from a single worklist of studies that needed to be read (all unread imaging cases except mammography), to complete the daily workload. The vast majority of cases were unassigned, and radiologists self-selected cases based on their specialty and preference. The single-worklist model is the most efficient means to load-balance the workload, based on research in operations management science [7].

The specific problem was that no radiologist knew how much work any 1 radiologist had done, causing speculation about each team member's contribution. Although monthly work relative value unit (wRVU) reports were available, these were summarily dismissed as being meaningless, owing to the substantial differences among individuals in number of hours worked, based on variable vacation, call duties, and extra-pay opportunities.

WHAT WE DID

The practice was retrospectively reviewed for radiologist productivity before and after implementation of a real-time productivity monitoring system (RTPMS). The RTPMS reports were produced every 2 hours and displayed the daily running total for all radiologists' individual wRVUs and modality count. The RTPMS reports were available on a cloud-based server, so radiologists could view them on their computers, tablets, and smartphones. The 12 months of review included a baseline period before the RTPMS was implemented (P1), and 3 periods with the RTPMS in place, with varying staff volume (P2, P3, P4). Each period was assessed for individual hourly wRVU productivity, individual daily wRVU productivity, unread worklist volume, central shift unread worklist volume, and daily percentage of "starving" radiologists (discussed later).

No financial incentives for productivity were present either before or after implementation of the RTPMS. The practice did not prospectively plan to downsize the daily staff volume at the onset of monitoring, and we did not compile data during the 12-month review period.

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Rather, the radiologists collectively made operating decisions based on their perception of the practice needs.

Time Periods

September 2013 through August 2014 was divided into 4 periods based on variables of staff numbers and whether the RTPMS was operating, as follows:

- P1: 4.0 radiologists without the RTPMS;
- P2: 4.0 radiologists with the RTPMS;
- P3: 3.6 radiologists with the RTPMS; and
- P4: 3.0 radiologists with the RTPMS.

During P1, and without the other radiologists' knowledge, the first author independently wrote the RTPMS software to convert Radiology Information System data into the RTPMS reports. The RTPMS report displayed the daily running total for all radiologists' individual wRVUs and modality counts.

One week before P2, the remaining radiologists were informed that an RTPMS was available for use and agreed to proceed with real-time monitoring. Starting in P2, RTPMS reports were generated every 2 hours, starting at 10:00 AM. After 7.3 weeks in P2, the radiologists collectively decided to downsize the primary shift from 4.0 to 3.6 radiologists, based on an intuitive perception of overstaffing, because the unread-worklist volume seemed low. After 17.3 weeks in P3, the radiologists collectively decided to downsize the primary shift, again based on an intuitive perception of overstaffing because the unread-worklist volume seemed low. The last period, P4, with 3.0 radiologists, comprised the final 7.4 weeks of the study.

Radiology Department Flow

Radiology departments can be diagrammed using the industrial manufacturing input-process-output (IPO) model, transforming inputs (patients) into in-process intermediates (unread cases), into final products (radiology reports) [7]. The registrants, technologists, and radiologists act as process resources that transform these flow units from 1 state to the next. Buffers between resources hold inventory from the immediate upstream resource until the immediate downstream resource is ready to process the flow unit [7].

For this study, "starving radiologist" is defined as an instance in which the unread case buffer totaled <7.22 wRVU. This low-buffer situation indicates radiologist overstaffing, based on the mismatch with too many radiologists (resources) relative to the inflowing work volume (unread cases). The total of 7.22 wRVU represents approximately 15 minutes of work for 4.0 radiologists and is the sum of 5 chest radiographs, each with 2 views: 1 ultrasound complete abdomen, 1 CT chest with contrast, 1 CT abdomen-pelvis without contrast, 1 CT head without contrast, and 1 magnetic resonance brain without contrast.

Measurements

Work relative value units (wRVU) were used to measure productivity and work volume because they are a standard industry means for weighting studies for time effort and are used by most practices for monthly and yearly productivity reports [6]. Each routine weekday primary shift during the 12 months was included in the review, excluding weekends and holidays.

Five measures of productivity and workload were calculated (Table 1):

1. Hourly wRVU productivity for each radiologist was calculated at 5-minute intervals between 7:30 AM and 5:00 PM, using the total for all cases completed during the previous 60 minutes. Individual averages were based on an

Table 1. Measures of productivity and workload

Measure	P1	P2	P3	P4
Radiologists (n)	4.0	4.0	3.6	3.0
Time period (wk)	20.1	7.3	17.3	7.4
Radiologist HWP average (wRVU/hr)	7.02	7.11	7.55	8.50
Radiologist HWP (SD)	0.63	0.47	0.37	0.50
Radiologist HWP range (wRVU/hr)	6.12-7.76	6.50-7.92	7.12-8.07	7.83-9.39
Radiologist DWP average (wRVU/d)	40.0	41.5	44.3	58.2
Radiologist DWP (SD)	17.8	16.5	16.7	12.0
Radiologist DWP range (wRVU/d)	14.5-58.1	15.5-56.0	19.2-57.8	47.7-68.6
Practice SWV (wRVU/d)	159.6	165.9	159.5	174.6
Practice CSUWV (wRVU)	16.8	13.5	10.7	13.6
Practice DPSR (%)	13.0	21.3	34.6	24.0

CSUWV = central shift unread work volume; DPSR = daily percentage of starving radiologists; DWP = daily wRVU productivity; HWP = hourly wRVU productivity; P = time period; SD = standard deviation; SWV = shift work volume.