Radiology Workflow Disruptors: A Detailed Analysis

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DESCRIPTION OF THE PROBLEM

Interruptions are a common and pervasive element of complex work environments [1,2], and the health care industry is no exception [3]. Workplace interruptions result in task switching and task shortening that can have deleterious effects on patient safety, workflow efficiency, and other quality outcomes [4]. By virtue of an increasingly complex work environment and the myriad responsibilities incumbent on radiologists, the radiology work environment is particularly susceptible to the effects of workplace disruptions [5].

Anecdotal experience at our academic institution suggests that non-image-interpretive tasks (NITs) consume a significant portion of the workday. These tasks include phone calls, pages, provider-to-provider consultations, study protocoling, examination monitoring, and image-guided procedures. Many of these NITs may, by virtue of their timing and frequency, be regarded as "interruptions" in that they divert attention from cognitively demanding primary image-interpretive tasks (IIT) and may adversely affect performance metrics such as accuracy, timely image interpretation, and reporting [5,6].

However, NITs have alternatively been proposed to be fundamental value-adding opportunities for the modern radiologist as a consulting physician and an imaging expert who helps guide patient care [7,8]. As such, many NITs are central to the ACR's Imaging 3.0™ initiative of delivering "all the imaging care that is beneficial and necessary and none that is not" [9]. However, disproportionate time and effort toward accomplishing NITs can result in a scenario in which the frequency, unpredictability, and inefficiency of NITs detract and divert important resources from a radiologist's primary image-interpretive responsibilities.

We designed a prospective observational study to quantify the spectrum of tasks undertaken by radiologists in our academic neuroradiology practice to better understand the frequency, nature, and duration of NITs in the reading room to serve as an initial barometer for the disruptions our radiologists experience during the workday. We anticipate that this study will inform efforts to generate distinct workflow patterns to efficiently address and accomplish NITs and IITs by minimizing interruptions and task-switching events (TSEs).

WHAT WE DID

A prospective, randomized, observational investigation of our academic neuroradiology reading room was performed over a 30-day period in October and November 2015. As the principal coordinator of reading room workflow, the "primary" reading room neuroradiology fellow was observed in 4-hour shifts over the observational period. Each of our institution's six neuroradiology fellows (four first-year fellows and two second-year fellows) rotated through this role as primary reading room fellow during the data collection period. Observation dates and times were randomized. When multiple fellows were assigned to the reading room in some capacity, the fellow who had no additional assigned tasks (medical student education, functional MRI duties, etc) was observed.

One-on-one observation was performed by two trained observers (A.S., T.H.), in shifts (8 AM to 12 PM, 1 PM to 5 PM, Monday to Friday), using a time and motion methodology. The nature and duration of tasks were quantified and recorded into one of the following predetermined task categories:

- IITs
  - Image interpretation, including dictation and report editing
  - "Staff-out" with neuroradiology faculty members
- NITs:
  - Phone calls and pager response (providers, technologists, and other radiologists)

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- In-room consultation with providers, technologists, and other radiologists
- Protocoling
- Teaching (dedicated teaching by attending radiologists, unrelated to staff-out)
- Out-of-room time (procedures and meetings)
- Personal time

Each new task occurrence while the subject was already engaged in another task was considered a TSE and documented in one of these task categories. Where relevant, certain NITs were further subdivided into additional categories to provide a higher degree of granularity with regard to origin, timing, and type. Activities not germane to the in-room workflow, including personal time and meeting time, were classified as neither IITs nor NITs.

Data were collected and analyzed using Microsoft Excel version 14.6 (Microsoft Corporation, Redmond, Washington). Total time spent on tasks in each category and total number of task instances in each category were calculated over the entire observation period. Mean TSEs per hour were calculated over the total duration of the study. Adjusted in-room observation time and adjusted TSEs per hour, which discounted time spent out of the reading room, were also calculated.

RESULTS

A total of 48:40:49 of observational data were collected over 14 shifts during a 30-day period, for a mean of 3:32:06 ± 00:44:30. The primary neuroradiology reading room fellow undertook 575 discrete tasks during this time period, resulting in a mean of 11.2 ± 4.8 TSEs/h. The maximum number of task switches encountered during a single 4-hour shift was 84 over a shift of 03:51:00. The "adjusted in-room" observation time was 37:00:03 ([total observed time] − [out-of-room time]). This corresponds to an adjusted mean of 14.9 TSEs/h. Granular task-specific duration, quantity, and statistical analysis are provided in Table 1, and time spent on discrete tasks is depicted in Figure 1.

IITs

A total of 18:21:02 was spent on dedicated image interpretation, with an additional 7:50:02 dedicated to staff-out. IIT duration was therefore 26:11:04, corresponding to 53.8% of the total observation time. One hundred ninety-two instances of primary image interpretation were recorded, with a median duration of 00:03:15. Forty-six instances of staff-out were observed, with a median duration of 00:06:07.

NITs

A total of 18:04:06 was spent on NITs during the observational period, including (total duration, number of TSEs, median duration) procedures (08:07:22, 11, 00:50:34), phone calls and paging (03:22:35, 139, 00:00:56), in-room consultation (03:05:17, 66, 00:01:44), protocoling (02:59:53, 48, 00:02:17), and teaching (00:28:59, 17, 00:01:21). NITs constituted 37.1% of the primary neuroradiology fellow's workday.

Other Tasks

A total of 04:25:39 was spent on tasks not classified as image-interpretive or non-image-interpretive, including in-room personal time (00:52:15, 31, 00:00:56), out-of-room personal time (02:01:32, 22, 00:03:20), and meeting time (01:31:52, 3, 00:27:34). Other tasks constituted 9.1% of the primary neuroradiology reading room fellow's workday.

OUTCOMES

Radiologists practice in a complex, demanding, and disruptive work environment. Although timely and accurate image interpretation remains the radiologist's primary clinical deliverable, success in the modern reading room environment demands the ability to efficiently negotiate a variety of NITs. To fully characterize the role of NITs in a busy academic practice, we quantified the nature and frequency of all tasks, including NITs and IITs, in our neuroradiology reading room.

We found that NITs constituted a large proportion of a trainee's (fellow's) workday, consuming more than one-third (37.1%) of total time in the reading room. In an attempt to balance non-image-interpretive and image-interpretative responsibilities in the reading room, the fellows performed on average 14.9 TSEs/h (adjusting for out-of-room time), with one fellow negotiating 84 TSEs in a single 4-hour shift. In context, these data suggest that a fellow in our main reading room can experience a TSE approximately every 4 min, reflecting the disruptive nature of the work environment.

The durations of all tasks, both NITs and IITs, were quite short, with median durations rarely tallying more than a few minutes. Importantly, image interpretation lasted just over 3 min (00:03:15) before a TSE occurred. This is significant in light of prior studies showing that average head CT interpretation times range from approximately 3.2 to 4.7 min [10], suggesting that currently, the median time spent on image interpretation is marginally sufficient for uninterrupted interpretation of a

Table 1. Duration and quantity of all reading room tasks performed by the primary reading room fellow with task-specific statistics

Task	Total Time (h:min:s)	Instances (n)	Mean (min:s)	Median (min:s)	Minimum (min:s)	Maximum (h:min:s)
Image-interpretive tasks						
Image interpretation	18:21:02	192	05:44	03:15	00:06	35:33
Staff-out	07:50:02	46	10:13	06:07	00:05	39:42
Non-image-interpretive tasks						
Procedures	08:07:22	11	44:18	50:34	04:45	01:28:11
Phone calls/paging	03:22:35	139	01:27	00:56	00:05	09:52
Provider study review	00:54:59	30	01:50	01:20	00:05	05:55
Provider order question	00:39:03	17	02:18	01:22	00:47	09:52
Provider other	00:04:55	5	00:59	00:42	00:10	01:56
Interradiologist consult	00:09:35	9	01:04	00:59	00:14	02:12
Technologist image check	00:27:22	18	01:31	01:00	00:05	04:35
Technologist protocol request	00:40:21	29	01:23	00:44	00:19	04:32
Technologist procedure question	00:05:47	12	00:29	00:25	00:11	01:17
Technologist other	00:02:33	2	01:16	–	00:41	01:52
Procedure/study consent	00:12:45	3	04:15	02:31	02:25	07:49
Other	00:05:15	14	00:23	00:15	00:05	01:33
In-room consultation	03:05:17	66	02:48	01:44	00:14	12:10
Provider study review	00:33:46	6	04:01	03:12	01:13	12:10
Provider other	00:07:00	2	03:30	–	00:20	06:40
Interradiologist consult	01:56:28	48	02:16	01:20	00:14	10:23
Technologist procedure question	00:16:59	7	02:36	02:10	01:03	05:34
Protocoling studies	02:59:53	48	03:45	02:17	00:18	26:39
Teaching	00:28:59	17	01:42	01:21	00:16	06:39
Other						
Meetings	01:31:52	3	30:37	27:34	26:47	37:31
Personal: out of room	02:01:32	22	05:33	03:24	00:13	25:42
Personal: in room	00:52:15	31	01:41	00:56	00:11	08:38
Total	48:40:49	575				

head CT study, let alone more advanced imaging studies (eg, stroke MRI or MR angiography). These data build on previous efforts to quantify radiology workflow disruptors and show that workflow disruptions extend beyond the on-call setting [5,6]. Our data also confirm findings from prior studies showing that NITs make up a significant portion of a radiologist's daily workload [8], such those described in the Vancouver Workload Utilization Evaluation Study looking at attending radiologists' daily workflow. However, we observed nearly double the number of interruptions per hour, an average of >11 TSEs/h compared with 6 interruptions/h in the Vancouver study.

The highly disrupted and complex nature of reading room workflow has potential negative implications for an academic educational mission. Diagnostic radiology remains rooted in an apprenticeship model of education in which the learner is actively engaged in practice with a mentor or an expert, and teaching at the workstation accounts for some of the most significant education a trainee will receive. In highly disruptive, complex clinical settings, physicians have been shown to prioritize tasks directly related to patient care [11] and truncate or abandon those tasks viewed as less critical [4]. The relatively short median duration of discrete staff-out sessions and the absence of any significant time commitment to dedicated teaching independent of staff-out suggest that a highly disrupted workflow may be forcing our physicians and trainees to curtail the educational components of radiology's apprenticeship model of training in favor of maximizing clinical productivity.

Although the data presented here are compelling, there were some limitations to our study. One limitation given the observational nature

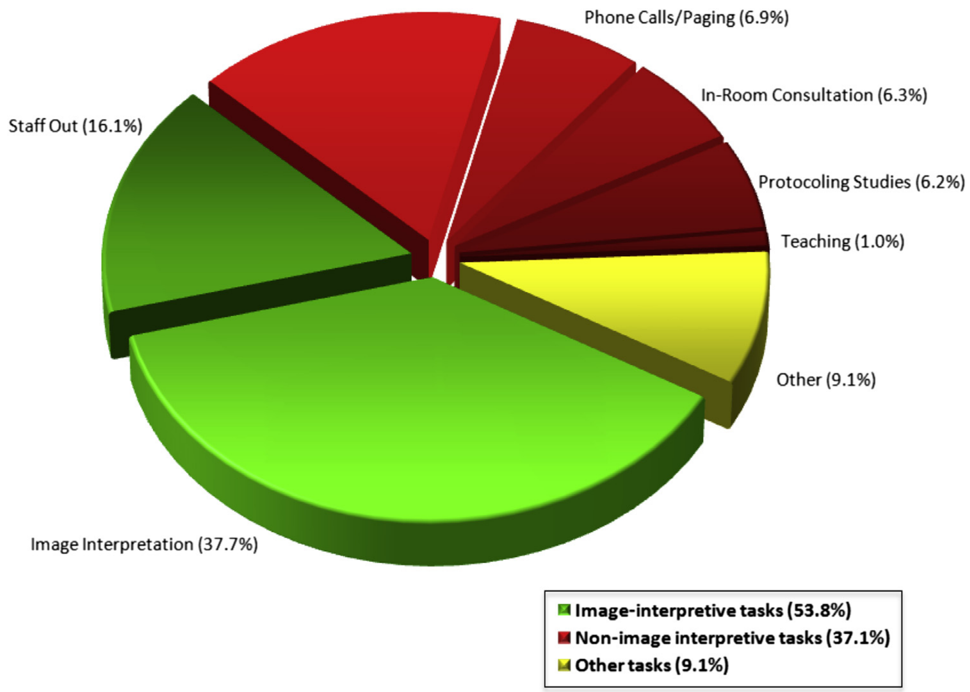

Fig 1. Pictorial depiction of the time distribution of tasks performed by the primary reading room fellow.

of this study is the Hawthorne effect, wherein bias is introduced in the form of subject behavioral modification by virtue of being observed. This was thought to be unavoidable in order to achieve the level of data granularity necessary to fully characterize our reading room workflow. Our results may also be limited with trainees of varying levels rotating through the reading room, with different degrees of experience and comfort handling varying NITs such as protocoling or managing in-room provider consultations.

CONCLUSIONS AND FUTURE DIRECTIONS

NITs account for a significant portion of the workday in our academic practice and may warrant a dedicated workflow for their completion. Beyond the total time spent on NITs, what was more remarkable was the frequency of TSEs in the reading room. We believe that there is tremendous potential to improve on current radiology workflows, and the burden TSEs place on our staff is informing efforts to design new workflow patterns to marginalize the most disruptive aspects of commonly encountered NITs while finding means to embrace NITs with greater value (such as in-room consultations).

Specifically, our data have informed the creation of a new "consult" role within our academic practice, effectively separating IIT and NIT workflows with the intention of minimizing workplace disruptions in an effort to facilitate improved workflow efficiency, increased IIT time, and enhanced trainee education. We anticipate that by separating these workflows, we can embrace existing underused value-adding opportunities and potentially improve overall efficiency (for both IITs and NITs), while continuing to provide consistent high-quality consultative services to our referral base in a more coherent and streamlined fashion. Moreover, we anticipate that a dichotomized workflow will allow closer collaboration and esprit de corps with our technologists and increased time spent on resident and fellow education.

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