**Title:** Burnout and Work-Work Imbalance in Radiology- Wicked Problems on a Global Scale. A Baseline Pre-COVID-19 Survey of US Neuroradiologists Compared to International Radiologists and Adjacent Staff

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ABSTRACT

**Purpose:** Worldwide, radiologists are experiencing increasing clinical workloads with associated increased burnout. This paper will review burnout definitions, prevalence, and causes. We will also share data from a survey of US neuroradiologists as an example of the impact of work-work imbalances from clinical overload. This article examines the impact on several key job indicators and upon the quality of the neuroradiology work environment in one nation. Finally, we will review proposals for ameliorating and preventing radiologist burnout.

**Method:** A survey was sent to members of the American Society of Neuroradiology (ASNR) practicing in the US. Selected measures included workhours and volume, burnout symptoms, subjectively reported errors, participation in non-clinical activities, perceived interpretation quality, results communication, and consideration of early retirement.

**Results:** Survey respondents (n=412) included 57.5% with teaching responsibilities. Cutbacks in teaching, mentoring, research and/or practice building were reported by 86.2% of respondents. Subjective errors were reported as occurring sometimes or more frequently in the majority of respondents (56.9%) and were increased with faster than optimal speeds of interpretation (P<0.001) and signing (P<0.001). At least one burnout measure was reported by 85.2% of respondents.

**Conclusions:** Increasing clinical demands in conjunction with a more challenging work environment impacts the ability of radiologists to perform core non-interpretive duties that are critical for success in both private and academic practice and is associated with burnout symptoms and adverse effects on quality. While this survey does not prove causation, the trends and findings are concerning and warrant both close monitoring and appropriate intervention.
Abbreviations:

ASNR – American Society of Neuroradiology

Highlights and key words:

Survey, Work environment, Burn out, Errors, Work force, value, clinical volume
A previous survey of the United States’ neuroradiology workforce in 2016[1] reported increasing clinical workloads and workhours. There was associated decreasing physician participation in critical non-clinical activities. This included core medical work, including teaching, research and practice building. The survey also demonstrated worrisome five-year trends regarding the prevalence of burnout symptoms, increasing thoughts of retiring early or changing careers from neuroradiology. This survey instrument raised significant implications for the possibility of a US radiology workforce shortage in the near future. Worse, this be exacerbated by a self-perpetuating cycle of burnout and worsened workforce shortages.

These single nation findings are unfortunately not unique. Instead, they are emblematic of a larger, more global problem of workplace burnout in the field of radiology. Burnout has been defined as a syndrome caused by prolonged job related stressors in which three key dimensions are an overwhelming exhaustion, feelings of cynicism and detachment from the job and a sense of ineffectiveness and lack of accomplishment[2]. Burnout and its consequences are not limited to the workplace, and it is not a benign phenomenon. It has been correlated with personal consequences such as substance abuse, depression, and suicide as well as workplace disruption from absenteeism, presenteeism (reduced productivity due to physical or emotional dysfunction), employment turnover and early retirement[3].

Burnout in radiology is a global issue, although a larger proportion of publications originate in the United States:

-A study from Poland showed high burnout rates in 37.1% of radiologists[4]
- A study from Hungary showed higher responses by radiographers compared to the average population in emotional depletion, depersonalization and personal efficiency[5].

- Ganeshan et al. surveyed the full members of the Association of University Radiologists (US) in late 2018 using the abbreviated Maslach Inventory and found that 79% had at least one symptom of burnout, with 29% meeting all three criteria burnout: emotional exhaustion, depersonalization and low personal accomplishment[6].

- Burnout can also be seen at the trainee level. A study from 2014 in the USA showed increased burnout in medical trainees[7].

- In a study from Saudi Arabia, one quarter of residents showed high burnout rates and over half had emotional exhaustion[8].

- Looking at academic chairs of radiology in the United States revealed a lower, but still significant rate of burnout with 5% of those surveyed meeting all three criteria for burnout[9].

More recently a survey of US academic radiologists revealed an incidence of burnout of 37% with intention to leave of 33% and sleep related impairment of 45%. The incidence of burnout was higher in women than in men[10]. Practice leaders in the United States are also very concerned about burnout and related issues. A survey showed that over half -55% considered burnout a very significant problem with an additional 22% considering it a significant problem[11].

Over five years ago, the issue was important enough that the ACR addressed this with a review of the issue including proposed remedies[12]. A more recent review emphasized the role that the current pandemic plays in exacerbating burnout and both acute and post-traumatic stress disorders[13].
Burnout can both be caused by and can be exacerbated by increases in the number and rate of case interpretations. As rates rise, the additional risks of errors create further stress. Shorter viewing times lead to increased miss rates[14]. More rapid reading and higher case-loads increase errors[15]. Another study showed that doubling the speed of interpretation increased the miss rate over 100%[16].

The Coronavirus-19 (COVID-19) pandemic disrupted work and lives around the world and provides a specific demarcation point for the work environment before the start of the pandemic and the adjustments to workplaces that began during the pandemic. In the United States, there was a 65.2% increase in installed home workstations and 73.6% switch from normal daytime shifts to internal teleradiology of surveyed practices without an increase in dependence in external teleradiology. These change were associated with decreased stress (64.8%) as well as improved or no change in turnaround time (96%)[17]. Although the pandemic resulted in daily stressors, ironically, it may have revealed one strategy in our tools to address workforce burnout, while preserving traditional measures of quality.

In this manuscript, we present pre-COVID-19 pandemic baseline data on the United States’ neuroradiology workforce for comparison with European data and future post-pandemic surveys in which lessons learned from and beyond the pandemic may affect the work environment and radiologist burnout.

MATERIALS AND METHODS

Survey methods (Appendix 1) were derived from the previous survey[1]. This instrument was launched at the beginning of September, 2017 and was open until the beginning of October, 2017. Initial technical issues with the survey prevented early respondents from progressing
beyond demographic data and were resolved within the first 3 hours of release. Survey data were then checked for quality.

**Statistical Methods**

Responses to the survey questionnaire were numerically coded as binary, ordinal or categorical variables, except for the radiologists’ age. For variables reported as a proportion, the exact (Clopper-Pearson) 95% confidence interval (CI) were obtained using simple binomial proportions. Correlations between the variables were assessed using Spearman rho. Appropriate non-parametric tests including Fisher’s exact test, Kruskal-Wallis test and logistic regression models were used for analysis. All multivariable logistic regression models employed Firth’s bias correction. The odds ratio (OR) and 95% Wald’s confidence interval (CI) were obtained. Hosmer-Lemeshow goodness-of-fit tests were performed. Kruskal-Wallis test and Fisher’s exact test were used for ordinal and categorical variables to determine if the responses to 2016 and 2017 surveys differed. Effects associated with P<0.05 were considered statistically significant. All analyses were performed using statistical software (SAS® version 9.4, SAS Institute Inc., Cary, NC).
RESULTS

Table 1 summarizes the characteristics of the respondents and their practices. Some respondents skipped questions. Hence, all percentages are accompanied by numerator and denominator. Results from the analyses for the topics of interest are provided below.

Errors

The perceived frequency of making errors “sometimes” (n=150) or more (“frequently”, n=36; “always”, n=4) was reported by 190/333 (56.9%,) respondents and was not associated with practice type (P=0.844). There was an association with radiologist’s gender (P<0.001; males: 52.4%; non-males: 79.3%). After adjusting for radiologist’s gender, making errors sometimes or more increased with the frequent or more than frequent need to interpret cases (P<0.001) and sign reports (P<0.001) faster than that considered optimal by the radiologist, and decreased with using advanced informatics (P=0.005) and with the availability of capable residents as perceived by radiologists (P=0.02).

Call volume and Workhours

An increase in call volume compared to 5 years ago was reported by 90/263 (34.2%,) respondents and was not associated with radiologist’s gender, teaching responsibilities, and practice type (P>0.626). After adjusting for the increase in the difficulty of calls over 5-years, the increase in call volume was associated with an increase in the hours worked per day (P<0.001) and decreased with the availability of capable fellows (P=0.038). The 5-year change in workhours, clinical workhours, workdays, and weeks worked per year were positively and
significantly correlated (P<0.001). Hence, an increase in any one of these four metrics was treated as an increase in workhours. The increase in workhours compared to 5 years ago was not associated with radiologist’s gender and teaching responsibilities (P>0.09), but was associated with practice type (P=0.042). An increase in workhours was reported by over half 58% of respondents. The increase in workhours was associated with frequent or more than frequent extension of the workday by at least 1 hour (P<0.001), an increase in number of cases interpreted per hour compared to 5 years ago (P=0.014), an increase in call volume compared to 5 years ago (P=0.002), an increase in the difficulty of calls compared to 5 years ago (P=0.022), and the frequent or more than frequent need to sign reports faster than that considered optimal by the radiologist (P=0.035).

Impact of workhour and call volume changes on non-clinical duties

The increase in workhours was significantly correlated with cutbacks in teaching, mentoring, research, practice building, voluntary service, attending continuing medical education (CME) conferences, reading medical journals, and other activities that require time away from work (P<0.018) Figure 1. Cutbacks (“frequent” or “always”) in teaching, mentoring, research, or practice building were reported by 86.2% of respondents. The increase in workhours was associated with a higher likelihood of cutbacks in mentoring (P=0.039), reading medical journals (P=0.049), and other activities that require time away from work (P=0.003). The increase in call volume compared to 5 years ago was significantly correlated and associated with cutbacks in mentoring (P<0.015), but not with other non-clinical duties (P>0.099).

Impact of workhour and call volume changes on well being
The increase in workhours was significantly correlated with experiencing greater fatigue, difficulty in relaxing after work, greater anxiety or depression, and diminished sense of enthusiasm at work (P<0.019). After adjusting for the practice type, the increase in workhours was associated with a higher likelihood of experiencing greater fatigue (P<0.001). The increase in call volume was not significantly correlated with experiencing greater fatigue, difficulty in relaxing after work, greater anxiety or depression, and diminished sense of enthusiasm at work (P>0.564).

**Factors associated with radiologists’ wellness**

The responses to the four questions regarding radiologists’ wellness (burnout measures) were positively and significantly correlated (Spearman rho>0.345, P<0.001) with 85.2% of respondents experiencing at least one burnout measure. Figure 2 shows the statistical associations of various work environmental conditions with each measure of burnout. Among the respondents, (76.6%) reported experiencing greater fatigue, 52.7% reported having difficulty in relaxing after work, 45.5% reported greater anxiety or depression, and 62.7% reported experiencing diminished sense of enthusiasm or effectiveness at work. Burnout measures were not associated with teaching responsibilities or practice type (P>0.108). A larger proportion of non-males compared to males reported experiencing greater fatigue (91.2% vs. 73.5%, P=0.003), having difficulty in relaxing after work (75.4% vs. 51.5%, P=0.001), and experiencing diminished sense of enthusiasm or effectiveness at work (84.2% vs. 58.1%, P<0.001), but not greater anxiety or depression.

The likelihood of experiencing greater anxiety or depression increased with increase in difficulty of calls compared to 5 years ago (P=0.003), with the frequent or more than frequent
need to interpret faster than that considered optimal by the radiologist (P=0.009), and with the frequent or more than frequent lack of time to discuss important abnormal results with clinicians (P=0.006).

Gender-adjusted likelihood of experiencing diminished sense of enthusiasm or effectiveness at work increased with increase in difficulty of calls (P=0.001), with the frequent or more than frequent need to interpret faster than that considered optimal by the radiologist (P=0.01), with errors occurring sometimes or more frequently (P=0.011), and decreased with increase in total financial package compared to last year (P=0.005) and with the availability of residents with equal or more capabilities (P=0.003).

**Early retirement and switching careers**

Among 325 respondents, 36.9% reported that they were either “somewhat likely” (20.9%) or “very likely” (16%) to retire earlier than they had initially intended when starting their practice. The likelihood of considering early retirement was not associated with radiologist’s gender, teaching responsibilities or practice type (P>0.37). After adjusting for the initially intended timeframe for retirement, the likelihood of radiologists’ considering early retirement was associated with experiencing difficulty in relaxing after work (P<0.001), diminished sense of enthusiasm or effectiveness at work (P<0.001), and reduced with changes made by practice administrator(s) to balance the clinical workload with non-clinical duties (P=0.006).

Among 326 respondents, 33/326 (10.1%, CI: 7.1%–13.9%) reported that they were “somewhat likely” (n=19) or “very likely” (n=14) to switch careers. The likelihood of switching careers was not associated with radiologist’s gender, teaching responsibilities or practice type
The likelihood of radiologists’ considering career change was associated with the frequent or more than frequent need to interpret cases faster than that considered optimal by the radiologist (P=0.008), with experiencing difficulty in relaxing after work (P=0.002), and with greater anxiety or depression (P=0.002).

A word cloud of text responses shows that dissatisfaction, stress, burnout, fatigue, and workload as common reasons for considering early retirement (Figure 3). Although “satisfaction” was also noted, it was always associated with a negative modifier (e.g., decreased job satisfaction, loss of job satisfaction).

**Poorly indicated studies**

An increase in poorly indicated or unindicated radiology examinations in the last 5 years was reported by 60.3% of respondents. The likelihood of an increase in poorly indicated or unindicated studies was associated with an increase in call difficulty (P=0.006) and was reduced with the availability of fellows with equal or more capabilities as perceived by radiologists (P=0.005).

**Perceived capability of fellows and residents**

The changes over the last 5 years in the perceived capabilities of the fellows did not vary with radiologist’s gender or practice type (P>0.103). Neuroradiology fellows were perceived to be equally or more capable than before by 61.8% of respondents.

The changes over the last 5 years in the perceived capabilities of the residents did not vary with radiologist’s gender or practice type (P>0.073). Residents were perceived to be equally
or more capable by 56.3% of respondents. The availability of residents with equal or more capabilities was associated with a lower likelihood of errors occurring sometimes or more frequently (P<0.001).

**Physician extenders and assistive technology**

The reported 5-year change in the use of physician extenders (Physician’s assistant, Nurse practitioner, radiology “supertech”) did not vary with practice type (P=0.321). An increase in the use of physician extenders was reported by 50.6% of respondents to that question and was associated with the use of advanced informatics (P=0.018). The reported 5-year increase in the use of physician extenders was not correlated with changes in workhours and call volume, or with poorly indicated orders (P>0.233).

The implementation over the last 5 years of advanced informatics, deep learning tools or other assistive technologies was reported by 24.7% respondents and their use did not vary with practice type (P=0.066). After adjusting for the increase in the use of physician extenders, the use of advanced informatics was associated with a lower likelihood of errors occurring sometimes or more (P=0.317).

**Clinical Productivity-based financial compensation**

In the United States, Relative Value Units (RVU) are used as a means of measuring clinical productivity and for calculating financial payment for radiology examinations. The use of productivity targets to determine individual radiologist financial compensation was reported by 33% respondents and was associated with practice type (P<0.001). The use of productivity
targets for compensation was less likely (P<0.001) with private practices (20%) compared to academic practices (50.4%), and did not differ between government hospitals (40%) and academic practices (P=0.413). After adjusting for practice type, the use of productivity targets to determine compensation was associated with practices that provided credit for non-RVU generating work (P<0.001) and was marginally associated with an increase in clinical hours compared to 5 years ago (P=0.074).

**Combined vacation and non-clinical professional time**

The change in combined vacation and non-clinical professional time from last year was not associated with the radiologist’s gender, teaching responsibilities or practice type (P>0.243). A larger percentage of respondents (13.7%) reported a decrease from the previous year in combined vacation and non-professional time compared to the 10.9% with an increase. The increase in the combined vacation and non-clinical professional time was associated only with changes made by practice administrator(s) to balance the clinical workload with non-clinical duties (P=0.006).

**Total financial package**

An increase in the total financial package from last year was reported by 35.1% respondents and was not significantly associated with the radiologist’s gender, teaching responsibilities or practice type (P>0.304). A decrease in total financial package from last year was reported by 20.8% with the remaining 44.2% reporting no change. After adjusting for the radiologist’s age, the likelihood of an increase in total financial package from previous year was
associated with an increase in the number of cases interpreted per hour (P=0.02) and changes made by practice administrator(s) to balance the clinical workload with non-clinical duties (P=0.001).

**Key Changes from last survey**

There were 432 and 412 respondents to the 2016 and 2017 surveys, respectively. Although some radiologists may have participated in both surveys, they were treated as independent samples. The results from the statistical analyses are summarized in Table 2. Statistically differing responses to 8 questions that were similar between the two surveys are summarized in Table 3 (expressed in percentage). Even though the median time interval till intended retirement was 11-15 years in both surveys, 38.4% report intending to retire within the next 10 years in the 2017 survey, compared to 31.3% in 2016.
DISCUSSION

Although the COVID-19 pandemic has interrupted work and life globally, it presents itself as a rare natural intervention in the workplace environment, forcing a change from the status quo. Economists have dubbed the profound increase in numbers of those quitting their jobs or changing careers during the COVID-19 pandemic, “The Great Resignation,” affecting workers in various fields around the world[18]. Its effects on the neuroradiology work force should be monitored. Our data represent a pre-pandemic US baseline against which future global work environments that incorporate serendipitous discoveries related to telework on burnout as well as other proven methods of burnout reduction can be benchmarked. Our data suggests that compared to radiologists in Poland[4], American neuroradiologists who responded to our survey have a greater degree of burnout symptoms. Similar to the radiographers in Hungary[5], US neuroradiologist survey respondents show a higher response to burnout questions than the general population[7,19,20].

While our previous survey inquired about thoughts but not intention of retiring early or changing careers. In the current survey, we inquired about intention to retire early or change careers. Worrisomely, the current survey showed that there was a statistically significant difference between the distributions with increased percentage of respondents intending to retire within the next ten years (38.4% versus 31.3%). In multivariate analysis, the intention to retire earlier than intended was statistically associated with two wellness measures (difficulty relaxing after work and diminished sense of enthusiasm or effectiveness at work) as well as changes by administrators to balance clinical workload and non-clinical duties. Similarly, the intention to change to a non-radiology career was statistically associated with two wellness factors (difficulty relaxing after work, and greater anxiety and depression) as well as a frequent need to interpret...
cases faster than considered optimal. This suggests that wellness and work environment are important drivers for the size of the future radiology workforce.

Although there is increasing demand of imaging and interpretation toward 24/7/365 coverage, staffing limitations and the time needed to train new radiologists limit the total available workforce for these clinical activities. To cover these time periods, without an increase in staffing, increased call, or time/frameshifting of work shifts would be necessary. Our survey identified that the increase in call volume was lower when fellows of equal or greater capability were available. Staffing turnover can be disruptive and better-quality fellows may help academic practices. Therefore, it should be rational to adjust call volume to minimize the negative effects on radiologist turnover and maximize the quality of fellows recruited to a training program.

**Wellness and Burnout**

Overall measures of burnout remain high among all respondents and were generally associated with worse working environments. Specifically, these measures were associated with increases in clinical hours, increased difficulty of calls, increased need to sign reports faster than considered optimal and decreased quality of trainees. Although personal resilience is an area of interest in healthcare[21–26] and was not assessed in this survey, clearly external factors related to work environment contribute to the overall sense of burnout. Without substantive changes to these factors, burnout will likely remain a problem within the workforce.

When interpreting gender differences in the burnout measures, caution is necessary. It is known that men and women experience burnout differently and that men may not believe that they become less effective when burned out, whereas women are more likely to stop and evaluate/question their efficacy [27]. Our data corroborates this gender difference. Whether this
difference in experience in burnout results in objective differences in efficacy is not known and should be an area of future investigation. Interestingly, Baker et al[28] found that male radiologists of every age group were more likely to have been sued for malpractice than age-matched female colleagues.

Financial Compensation

The use of quantitative clinical productivity targets in the United States for determining radiologist compensation was interestingly more common in academic practices (50%) and government hospitals (40%) and least common in private practices (20%). Given that academic practices may serve as tertiary care referral centers for patients with complex medical problems, it might be expected that the effort required to interpret exams on these patients would discourage the use of clinical productivity-based compensations, whereas private practices might be incentivized toward clinical productivity-based compensation.

Changes in financial compensation were positively correlated with two factors, one more intuitive than the other. The association of increased financial compensation with increased number of cases per hour is intuitive, however, the positive association between changes made by practice administrators to balance clinical workload with non-clinical duties is less intuitive. It is unclear whether the increase in financial package reflects a reduction of non-clinical duties to allow increased clinical workload, or some other factor, which allowed an increase in financial compensation while finding another method to balance non-clinical and clinical duties. Given that increased combined vacation and non-clinical professional time was also significantly correlated with practice changes to balance clinical and non-clinical duties, it is felt less likely
that the balance of changes was toward more clinical work than less. This is an area of interest for future investigation.

**Quality of Work Output**

Self-reported rate of interpretive errors remained worrisome with 56.9% of respondents making errors at least sometimes, frequently or always and was associated with interpreting and signing reports faster than considered optimal. The likelihood of these errors reduced with the use of advanced informatics and better-quality trainees. The types of advanced informatics in place were not specifically evaluated. Work environments that require increased interpretive speed clearly have negative self-reported and quantitative[15] effects on quality of neuroradiologists’ core function, accurate interpretation of clinical imaging exams. Whether the positive influence of advanced informatics tools and better-quality trainees can outweigh the negative effects of a work environment requiring increased interpretive speed is a question for future study.

The results are intuitive for self-reported blame for errors compared to blame on workload. There was a statistically significant shift in proportion of blame from that assigned to self to that assigned to workload factors from the present to five years ago. In multivariate analysis, the shift in responsibility from self to workload was associated with a greater frequency of needing to interpret faster than considered optimal and with lack of time to discuss important abnormal findings. Although the result is intuitive, in the setting of ever-increasing workload demands, the solution is not.
Comparison to the Previous Survey

Year-to-year changes were mixed in similarly worded questions. Worryingly, an increased percentage reported an intention to retire within the next 10 years, potentially exacerbating a workforce shortage. Although burnout measures were not statistically different, 2017 survey indicated an increase in combined vacation and non-clinical professional time associated with decreased cutbacks in local practice building and reading journals, and increased cutbacks in volunteer contribution to professional societies.

The Job at Hand

High-level administrators are in a challenging leadership position, with many facing competing issues. This many include balancing enterprise-wide, as well as departmental fiscal challenges, with the need for adequate staffing to improve radiologist working conditions and morale. While it is outside of the scope of our manuscript to provide a globally applicable solution, we surmise that although balancing finances and staffing may initially appear diametrically opposed, an investment in a balanced and happy workforce may potentially result in better financial performance. A less burnt out workforce may make fewer interpretive errors resulting in improved patient care and satisfaction, which enhances departmental reputation. These effects may result in financial rewards to the system: 1) a direct decrease in costs for example, from correcting clinical mistakes, as well as from reduced radiology recruitment costs if turn-over is decreased, 2) a potential increase in revenues if fewer errors are made and outcomes based rewards are earned, and increased revenue from patient referrals for higher perceived quality. If increasing staffing is not a possibility, investment in force multipliers, such as artificial intelligence-based tools or radiologist extenders that can improve efficiency,
accuracy and potentially morale in the setting of increasing workloads may be an option. This is by no means an exhaustive list of solutions, but merely a framework from which further practice-specific changes can be discussed.

Limitations

This survey has several limitations: it was voluntary, and it is possible that responders differ from non-responders in the broader radiology community. As a survey and not an audit, it is open to response and recall bias. Questions regarding workload were subjective, rather than quantitative and normalization of responses to workload was not possible.

CONCLUSION

Burnout has become a global challenge to the sustainability of radiology practice. Worrisome trends in the work environment and potential downstream effects on core work output, as well as neuroradiology as a profession, have continued in the setting of increasing clinical work demands. There is a persistent incidence of burnout symptoms and pressure on quality of core work output. Providing a solution to these issues is beyond the scope of this manuscript; however, these data should provide a pre-COVID-19 reference for discussion to investigate and address these issues in the global neuroradiology work environment.
REFERENCES


Figure 1: The percentage of respondents reporting cutting back time spent performing various non-clinical duties who consider those duties part of their job description. This specifically excludes respondents who answered, “Not Applicable” to those duties.
Figure 2. Statistical associations with work environmental factors and each burnout measure. Arrows indicate either an increase (↑) or a decrease (↓).
Figure 3. Word cloud of text responses for reasons for early retirement in the “other” category. Larger text size indicates greater frequency of a word in responses. “Satisfaction” was always associated with a negative modifier.
Table 1: Characteristics of survey respondents and their practices
Appendix 1: Survey instrument used for members of the American Society of Neuroradiology