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RESEARCH ARTICLE

Exploring Inter-Departmental Variation in Departmental Stress Using Medical Claims Data

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Abstract:

Background:

Over the last several years there has been an increasing emphasis on making organizations healthy and functional places to work.

Objective:

To develop a scale of departmental stress from residualized, aggregated medical-claims data.

Methods:

Following the strategy of using aggregated individual data to infer the characteristics of larger units, we use medical-claims data from a metropolitan research university. Logged residuals of average individual medical claims are aggregated over a two-year period, controlling for compositional (% Female and % 50 and older) and other factors (Department size and Presence of a lab using toxic chemicals). We then examine the internal consistency and factor structure of a scale constructed from a reduced-set of 14 ICD-9 medical claim categories.

Results:

Our results indicate a dominant primary factor that explains 44% of the common variance. The scale is also internally consistent, with a Cronbach's Alpha of .87.

Conclusion:

We conclude that there is meaningful, coherent variation in medical claims across departments that is tentatively interpreted in terms of departmental stress.

Keywords: Context, Embodiment, Organizations, Risk, Stress, Wellness.

INTRODUCTION

Over the last several years, increasing attention has been given to structural and cultural factors within organizations that are supportive of health and/or associated with making workplaces more healthy and functional places to work—primarily through perceived workplace health support initiatives - and sensitizing researchers and practitioners to the importance of workplaces in generating job strain and other stressors [1 - 10]. The objective of our work is to

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provide a meaningful, easy-to-gather tool derived from routinely-gathered organizational data for assessing levels of departmental variation in stress (*i.e.*, levels of dysfunction).

A basic assumption to which we adhere is that when exposed to stress, individuals break down before organizations. We treat this assumption as primitive, pointing out that organizations have a variety of methods for maintaining themselves at the expense of individuals. Individuals with health and/or other problems for example may retire, leave, die, be dismissed, isolated, shunted off to the side, or treated and reintegrated into their jobs. A parallel assumption is drawn from Kreiger's work on embodiment [11, 12]. Embodiment represents an interactive, cumulative process by which "bodies tell stories about - and cannot be divorced from - the conditions of our existence" [12]. We fully agree that bodies reflect the experiences in context through which we have lived. This is initially an individual story. But just as there may be collective stories that reflect commonalities across people in similar situations [13], so it may be that the bodies of people sharing a common work environment reflect the extent to which these environments are stressful.

To best capture the distal experience of stress, we used medical claims to capture health-related individual-level variation, and then inferred the characteristics of context from aggregated individual behavior in the form of rates, in the tradition of Lazarsfeld and Mensel [14], and Baudelot & Establet [15] with specific reference to suicide. The basic logic follows the taking of what individuals do, experience, or feel and transforming those into a *rate* bounded by time and place, which permits inferences regarding the characteristics of places, be they organizations or communities. Suicide, for example, is a serious consequence of exposure to stress, and when it is associated with workplaces, it has been viewed as saying something about individuals and also about the organizations in which they work [16]. That emphasis on saying something about organizations becomes clearer when one is talking about rates. And it becomes clearer still if one moves away from suicide to talk about a variety of illnesses whose rates might be driven in part by stress. Following such a protocol, the result is a broad net of individual-level diseases associated with exposure to stress and strain, such as acute recurrent Coronary Heart Disease events [10, 17 - 21], cancer [22 - 24] or disease and other consequences more generally [2, 3, 8, 25 - 31].

Research has suggested that lifestyle choices and illness may be exacerbated by stress - and reciprocally may also contribute to stress. For example, in a meta-analysis of the impact of work stress on cardiovascular disease, Kivimaki *et al.* explicitly pointed to the possibility that at the individual level, the relationship between stress, risk factors, and disease may be reciprocal across time [19]. Our interest however is not in disentangling reciprocal effects at the individual level - rather, our interest is in examining the way medical claims could be used as a convenient way for tracking the impact of mutually reinforcing processes at the individual level (compatible with Krieger's sense of embodiment as a continuing, cumulative exchange process between people and their environments [12]) and then in using what we learn in aggregated form to say something of the risk of social units within an organization at a given point in time.

METHODS

Design

We used a quantitative, cross-sectional design embracing two consecutive years of data (2010-2011).

Setting

The site for data gathering was the University of Louisville (UofL). UofL is a state-supported, self-insured, metropolitan research university with more than 6500 employees on three campuses with 12 colleges and schools. Get Healthy Now (GHN), the resident wellness program, was launched in 2005, has been the recipient of several regional and national awards [32].

Subjects

After receiving expedited approval from the IRB (11/9/2015), and spending more than 2.5 years negotiating with the Office of Privacy and the Office of Institutional Research over legitimate issues of maintaining privacy, we developed a sample of 47 academic departments with 25 or more faculty and staff drawn from the University of Louisville for the years 2010-2011. We began our analysis with a sample of 3711 faculty and staff who were employed at UofL for 2010 and/or 2011 in academic departments, excluding all employees who were in administrative departments. We first excluded the 513 employees for whom, even after some considerable effort, we could not find information regarding their insurance coverage, leaving us with 3198 faculty and staff with connected insurance-claim

information, and we eliminated 31 individuals who had average medical claim usage of \$50,000 or more so as to reduce skewness (sensitivity analysis revealed that leaving the outliers in the sample did not affect results). Our final sample included $N = 2175$ individuals drawn from 47 academic departments with 25 or more individuals.

Measures

In our analyses, we controlled department size, since even if medical claim generation were a completely random phenomenon, larger departments would be expected to have higher numbers of claims. To control for this, we attenuated the variation in department size by focusing only on departments that had at least 25 members, a decision based both on de-identification strategies and the stability of estimates. As a further precaution to alternative explanations, we also controlled department size statistically, creating rates.

Additional risks we considered included ergonomic and specific-exposure-related effects. We limited potential variation in ergonomic risk by focusing only on academic departments. Because academic departments vary in their potential exposure to toxic chemicals - as well as their exposure to safety constraints from NIOSH - we opted to assign a 1 to those departments that have at least a modest exposure to toxic chemicals and a 0 to those which have no such exposure. We also controlled for compositional effects attributable to characteristics of individuals working within departments [33]. Some departments, for example, may have had higher average medical claims because of having higher proportions of female and/or older workers.

A hallmark of our approach is the use of routinely-gathered data derived from aggregated medical claims. Much of the work estimating organizational stress levels has used surveys to identify job stressors [8, 28, 29, 34 - 36]. Such approaches will be very useful for follow-up work in departments where dysfunction has been identified. Our work complements the use of questionnaires by offering the prospect of a flow of readily available information regarding stress "hot spots." In doing so, we lean heavily on the concept of embodiment. As Krieger reminds us, our bodies tell stories about the conditions of our existence, and they do so in a way that "often-but not always-match people's stated accounts; and bodies tell stories that people cannot or will not tell, either because they are unable, forbidden, or choose not to tell" [12]. We are simply enquiring as to whether one of the *collective* stories that can be told involves variations in the stressfulness of the environments in which people work.

Medical claims have three components. A claim is the sum of all charges submitted for a given person on a given day. Claims are broken up into "lines of service" where there may be multiple lines of service for each claim. Lines of service are also broken up into "discrete charges" and there may be multiple charges for each line of service. For example, if one were to go to a primary care physician to get a flu shot, there might be three lines of service (the office visit, the flu shot, and perhaps a test for allergens). Suppose 10 different allergens were tested for. This single medical claim would then have 10 service charges for the ten different allergens tested for, one charge for the flu shot and one charge for the office visit. All of these in total would constitute the claim and a charge would be associated with that. Instead of breaking claims down by lines of service, we used the total dollar amount paid claims by department.

Medical claims result from chronic and acute diseases, anxiety and other mental health issues, ergonomic factors, accidents, and risk factors that reflect how people may cope with the stresses of their work lives (smoking, drinking and over-eating). There are several alternative ways of categorizing claims. For example, there are over 5000 5-digit ICD-9 (International Classification of Diseases, 9th edition) diagnosis codes [37]. These may be aggregated to the 3-digit code level, yielding 840 separate codes, which are routinely aggregated into 19 major categories reflecting the major body systems (Digestive System, Respiratory System, *etc.*) and other groupings which cross all body systems such as Neoplasms or Infectious and Parasitic Diseases.

We began our analysis with the standard 19 categories. We eliminated codes that were assigned to women only (Complications of Pregnancy, Childbirth, and the Puerperium) so as to physically reduce confounding with differing gender proportions in departments and more generally to limit diagnostic categories that do not apply to both genders. Similarly, the category Conditions Related to the Perinatal Period was excluded as the codes assigned to this category are applicable to the actual fetus or newborn and not the actual employee (currently services associated to a fetus or newborn are billed under the mother's member identifier since the fetus/newborn will not have documentation of coverage at the time the services are performed). We excluded Congenital Anomalies because the number was very small ($n = 84$) and because there was no other category to which it could logically be merged. We eliminated the Supplementary Classification of External Causes of Injury and Poisoning because none of these diagnosis codes should be a primary diagnosis. These diagnosis codes all start with the letter "E" and are used to provide further description for

an accident, injury, or poisoning to allow for more detailed analysis for example, E801 railway accident involving collision with other object. According to coding conventions, if a person had a concussion from a railway accident, the concussion is the primary code (and the associated charges would be assigned to the Diseases of the Nervous System) and then the "E" code would be assigned but only used for analytical purposes to further describe the cause of the concussion. We also combined Diseases of the Circulatory System and Diseases of the Blood and Blood-Forming Organs into a single diagnosis category. The volume of members, cost and services in the category Diseases of the Blood and Blood-forming Organs were too low for a separate category, as we were concerned about maintaining confidentiality for the small number of employees. In sum, we utilized 19 diagnostic categories per the ICD-9 CM coding hierarchy. We eliminated 4 of these and combined 2 categories, resulting in a total of 14 diagnostic categories. We excluded all charges not incurred in 2010-2011, and those not emanating from members in the study sample of 2175 from the 47 academic departments.

The Microsoft SQL Server database application was used to store all data. An employee listing which identified the employee's work department was connected to claims/eligibility data using first name, last name, and date of birth. Queries were then written to obtain the appropriate employee cohort for inclusion in the study. Only employees that existed in both data sources (employee listing & claims/eligibility data) were included in the study. Cost outliers were defined as any employee with \$50,000+ claims for a single year (2010 or 2011) or any employee that had \$100,000+ in total claims (2010+2011). In order to be assigned to any of the diagnosis categories, an employee would need to have at least one medical claim with the diagnosis completed. However, some employees did not have claims for the defined incurred period (2010-2011) and would not be included in any of the ICD-9CM diagnosis categories even though they had health coverage under the University medical plan. In order to include these employees in the study, a 1 (representing a claim of one dollar) was assigned to each of the category codes for these individuals who had no claims. Thus, if a person had codes for three different claims for 2010-2011, they would have the actual dollar amount for those three claims, and for the other claims would have a 1. The minimum with this scheme (necessitated by the fact that we were logging medical claims data) would be \$14. There were 397 such individuals in 2010-2011.

To clarify, claims are not medical records. They are a step removed from medical records and focus only on those things for which charges and reimbursement are expected. Hence, in addition to the sources of unreliability and bias that might be present in medical records, claims data undoubtedly have additional biases associated with them. In a comprehensive review of such issues, Ferver, Burton, and Jesilow (2009: 12) argued that claims data existed for the purpose of "generating income for individual and institutional providers and those who produce them are primarily guided by this function" [38]. In short, claims might be inflated so that individuals and the departments in which they work may appear sicker than they actually are an issue which also makes problematic the separation of preventive and treatment-related costs. For our purposes, however, if the bias is constant across ICD-9 categories, such a bias would not affect our results and would be equally applied across the sample.

Information on Gender, Age, and Department Size were available through the Office of Institutional Research and data on Labs which used toxic chemicals were available from the Office of Safety.

Analysis

After logging average medical-claim usage for 2010-2011 at the individual level to moderate the skewness in the distribution owing to the presence of individuals in departments who had no medical claims, OLS was used to estimate logged residuals, controlling for department size, gender, age and the presence of a lab using toxic chemicals.

This yields a data set on 2175 individuals that is subsequently aggregated into 47 departments which have different work environments but which also have a certain historical, substantive integrity as discrete workplaces within the university. Any analytic technique we chose to use must have respected the integrity of these boundaries. Hence, to test the assumption that there was an internally consistent dominant factor underlying the scale developed from the 14 ICD-9 medical-claim categories, we performed a principal components factor analysis and assessed the reliability of the resulting scale.

RESULTS

The primary question addressed in this paper is whether or not at the departmental level, a scale or index constructed from aggregated, logged residuals (controlling for gender, age, department size and presence of a lab in which toxic chemicals are used) is reliable and has a dominant underlying factor. An implication of our belief that codes for medical claims are driven by stress is that there should be an underlying continuum that each ICD-9 code ties into.

Table 1 presents the descriptive information concerning variables used in the analysis at the department level. We transformed the original set of 19 categories into a set of 14 that should work almost equally across demographics.

Table 1. Means, Medians and standard deviations of variables used in the analysis (N = 47 academic departments, 2010-2011).

Variable	Mean	Standard Deviation	Median
% Female	.56	.22	.56
% aged 50 and over	.41	.13	.40
Department Size	46.28	23.98	41
Average Adjusted Medical Claims	\$3797.64	1537.01	3690.32

We performed a principal components analysis of these 14 ICD-9 categories. Table 2 presents the summary results of this analysis. The 14 ICD-9 categories were strongly interrelated at the departmental level, indicating, for example, that those departments that have high usage attributable to cardiovascular problems are also at risk of having high usage attributable to respiratory or musculoskeletal problems, and conversely, that those departments which have relatively low respiratory problems that result in medical claims are also likely to have a lower volume of cardiovascular problems. As a test of reliability, we subjected the scale derived from these residuals to a reliability analysis to explore additional psychometric properties. Cronbach's Alpha for the residualized, logged medical claims was .87.

Table 2. Principal components analysis summary for the 14 ICD-9 medical claim categories.

Component	% Common Variance Explained*	Cumulative %
1	43.84%	43.84%
2	9.46%	53.30%
3	8.03%	61.33%

* These figures represent the extent to which the variance among the 14 ICD-9 categories can be explained by underlying factors. The most important underlying factor explains about 44% of the variance shared by these different disease categories, while the next most important factor explains only about 9.5%.

These results reveal the presence of a single, dominant primary factor not attributable to variation in compositional factors, department size, or the presence of a lab that uses toxic chemicals. This single, dominant primary factor accounts for 44% of the variance in aggregated average logged medical-claim residuals across departments. In contrast, the second most prominent factor explained less than 9.5% - about a fifth as much variance explained by the primary factor.

DISCUSSION

Our goal was to develop an index of relative worksite stress using medical-claim residuals aggregated by department, speaking to the characteristics of an aggregate entity using individual-level properties [14]. To follow a classic analogy used regularly within the social sciences, it may not be possible to explain adequately all of the causes of an individual's chances of committing suicide, but it is still possible to use rates of suicide to help us understand the characteristics of environments in which such tragic events take place - an analogy we have understood as social scientists since Durkheim (Baudelet and Estabiet 2009) [15]. Couched within the organizational context of our work, suicidal tendencies are relatively rare and would be a subset of mental health ICD-9 category. Our finding that the 14 ICD-9 categories share a good deal of common variance indicates that focusing on any single category by itself (musculoskeletal, cardiovascular, *etc.*) may also be too narrow for some purposes. Just as suicides are difficult to predict at the individual level but suicide rates may tell us something about the stressfulness and dysfunction in the "suicidogenic" areas in which such rates are higher, so, any given individual's medical-claim usage may be difficult to predict, but rates of such patterns may tell us a lot about the stressful nature of the work environments characterizing different departments, controlling for relevant variables.

This logic also appears to be compatible with interpretations of embodiment, given the inseparability of bodies and the contexts within which they have been living and working. The stories bodies tell through their illnesses seem to have a common thread that is traceable to the stressfulness of the contexts within which they work [11, 12]. The central question for social epidemiology may be "who and what is responsible for population patterns of health, disease and well-being," but a derivative question may be, what can patterns of disease tell us about the conditions that engender

them? This is the same logic as that used by those using suicide rates to infer the suicidogenicity of environments which people inhabit, but on a broader, more reliable scale.

Our results documenting a strong underlying factor across medical-claim categories after appropriate variables have been controlled builds on the many studies that have established a relationship at the individual level between job stressors and diseases as diverse as cancer [22 - 24], heart disease [12, 17 - 21], psychological distress [17], suicide [16], musculoskeletal disorders [8, 31], and other conditions [27]. While at the individual level, stress may manifest itself as disease in a variety of ways that are conditioned by genetic, physiological and other factors, at the aggregate level of departments, given that stress may be a common factor, it is reasonable to expect that those departments that are relatively high in some categories will be relatively high in others. Hence, the resulting scale of risk profiles may be *tentatively* used to identify the level of stress present in departmental work environments. It should be noted, however, that these 47 departments vary also in the nature of their charge, their material circumstances and their relationship with their students and outside groups, and other external and internal organizational factors which may impinge upon them. Hence, the emphasis on *tentative* should be taken seriously.

A recent meta-analysis of the relationship between workplace stressors and a triangle of health outcomes (self-identified poor physical and mental health, physician-identified poor health and mortality) lend credence to our tentative interpretation [4]. The authors analyzed 228 studies that embraced some combination of 10 different workplace stressors (long working hours, shift work, low worker control, poor social support and so on), concluding that exposure to such stressors was roughly comparable to exposure to second-hand smoke - increasing the odds of illness by roughly 50%. Our approach has been to use this established connection between work stressors and illness, following the suicide analogy, to infer the presence of workplace stressors which vary across departments.

CONCLUSION

Medical claims can be a valuable source of information regarding levels of stress in departments within an organization. Since claims are driven in part by stress at the individual level, by aggregating them and removing sources of compositional bias (% female and % 50 and over), along with controls for exposure to labs using toxic chemicals and department size, the resulting risk profile measure scales nicely (Cronbach's Alpha of .87) and has a dominant primary factor that explains more than 40% of the common variance. We tentatively conclude that this meaningful, coherent variation may be interpreted as departmental stress, and that such a scale will help refocus the discussion of organizational health toward a more comprehensive approach.

RECOMMENDATION FOR FUTURE STUDY

Given the emphasis on identifying the characteristics of the work environments that members of a department share, the relevant criteria for such analyses in the longer term is whether department risk profiles help focus attention on the possibilities of changing work environments to moderate stress, and make sense of other organizational phenomena such as productivity and adaptability across time. To move further with such analyses as a practical tool, researchers need to understand whether subsets of codes are more useful for identifying departments at risk, how departmental risk changes through time, the critical events and decisions that are conducive to departments moving in one direction or another, how patterns of departmental risk are associated with productivity and creativity, and what other internal and external organizational factors need to be considered - in short, a host of issues. The work that we have undertaken provides a step in that direction.

AUTHOR'S CONTRIBUTIONS

All of the authors have contributed to this study and agree to submission to the Open Public Health Journal for publication.

CONFLICT OF INTEREST

We do not believe that there is a conflict of interest on the part of any member of the research team. The method discussed in this article has recently had a US provisional patent application filed on it through the University of Louisville's administrative offices. Any questions regarding that patent may be directed to the University of Louisville Office of Technology Transfer at thinker@louisville.edu. That being said, none of the authors have received any financial remuneration for participation in this research, nor have any of the authors signed an agreement that would limit our presentation of either positive or negative results, nor are we subject to any sort of review of any paper before

submission.

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