Problem Density, Workload, and Medical Error in Primary Care Practice: a WREN Study

Final Grant Report to the Agency for Healthcare Research and Quality

1 R03 HS16026-01 (PI: Jonathan Temte)
Dates: 6/1/2006 through 5/31/2008
Project Officer: Dr. David Meyers

Wisconsin Research and Education Network
University of Wisconsin Department of Family Medicine

Study Team:

Jonathan L. Temte, MD/PhD
John W. Beasley, MD
Michael Grasmick, PhD
Richard Holden
Ben-Tzion Karsch, PhD
Beth Potter, MD
Paul Smith, MD
Lisa Kietzer
Peggy O'Halloran
Betsy Doherty, MS-2

CONTENTS

ABSTRACT

Purpose: To evaluate relationships between number of problems per encounter (NPPE), clinician workload (CWL), and medical error

Scope: Prospective study involving 31 clinicians and 609 patients affiliated with the Wisconsin Research and Education Network

Methods: Patient demographics, CWL using the NASA-TLX, NPPE, and estimated error were collected. Relationships between (1) NPPE and patient factors, (2) NPPE and CWL, and (3) CWL and perceived medical error (PME) were assessed using ANOVA, correlation analyses, and linear regression techniques. ANCOVA identified clinician differences.

Results: Clinicians managed an average of 3.3 problems per encounter and a mean CML of 47.6. NPPE was highly correlated to CWL; CWL increased 7.2% for each additional problem ($P<0.001$). Individual clinician differences and NPPE accounted for 52.7% of variance of CWL. CWL was positively associated with perceived medical error ($P<0.001$); PME increased by 3.5% for each additional 10-point rise in CWL. Individual clinician differences and CWL accounted for 59.1% of variance of PME. The resulting complexity of a clinical encounter, based on the number of problems, contributes to the workload experienced by the clinician. This in turn may affect the likelihood of medical error. Efforts to reduce clinician workload may help reduce potential medical errors.

List of Products:

Temte, J.L., M. Grasmick, J. Barr, J. Kunstman, A. Jaeger, and J.W. Beasley. Encounter problem density in primary care: a better measure of complexity? 35th Annual Meeting of the North American Primary Care Research Group. October 20-23, 2007. Vancouver, BC.

Temte, JL, Grasmick M, O'Halloran P, Kietzer L, Karsh B, Smith P, Beasley J, Doherty B. Mental workload in primary care. AAFP National Research Network 8th Annual Convocation of Practices and Networks, March 8, 2008, Colorado Springs, CO.

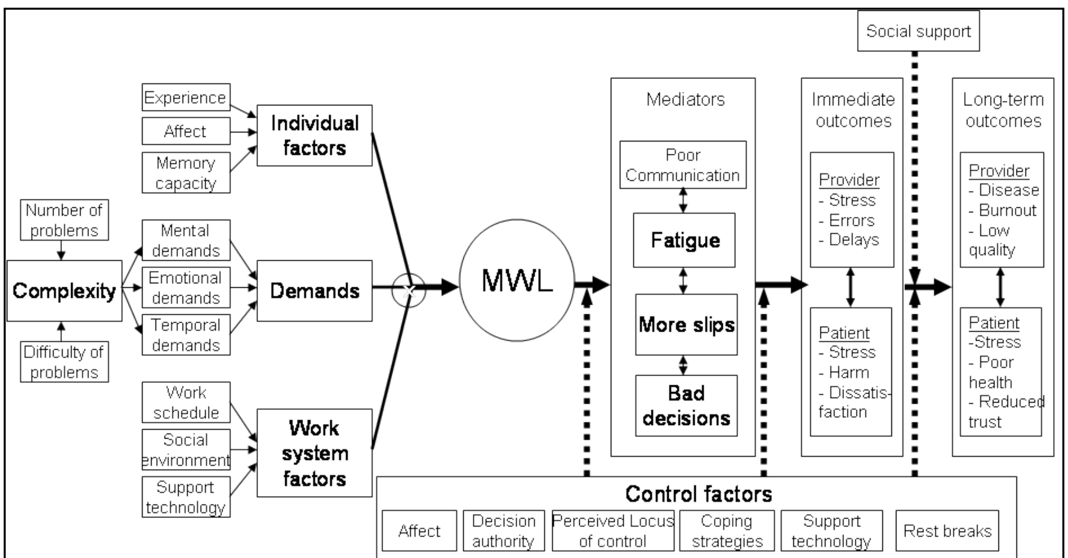
O'Halloran P, Temte J. Complexity of Family Practice: A WREN Study. AHRQ 2008 PBRN Research Conference June 11-13, 2008, Bethesda, MD.

INTRODUCTION

Primary care medical practice is chaotic, messy, and complex. Despite the intrinsic value of understanding this uniquely interesting system, there have been only a few studies aimed at dissecting the process of delivering primary care. Some of the best descriptive studies in primary care have emerged from direct observation of clinicians and patients during healthcare encounters and confirm this complexity [1]. From these observations, two unavoidable constraints emerge for family and internal medicine physicians in primary care practice: breadth of content and lack of time. Primary care of adults requires complicated and diverse sets of knowledge in many, often nonoverlapping and competing, content areas. For example, the initial training of family physicians must meet the incredibly broad and diverse content areas that form the program requirements set forth by the ACGME [2].

A recently published Wisconsin Research and Education Network (WREN) study explored the number of problems managed by family physicians at each patient encounter [3]. On average, family physicians managed 3.05 problems per encounter. From data collected on 810 patient encounters from WREN practices using the PRINS_2 instrument, the length of the average patient visit was 17 minutes (Temte, unpubl. data). Consequently, an average problem density estimated for Wisconsin family physicians is 10.8 problems per hour (5 minutes 34 seconds spent per problem).

To better define and understand the processes of primary care, a human factors engineering approach was proposed by our team resulting in a conceptual systems model for complexity within primary care (Figure 1). From a human factors point of view, this model is a



Notes
1. The above components are merely examples. Clearly, others may be added and this is all amenable to modification.
2. This model, despite its many components, is probably a simplification of the true nature of mental workload. However, this model (or something like it) can serve as a conceptual base camp from which studies are launched. The boxes with shaded backgrounds represent variables that can potentially be measured—albeit not all in the initial study. However, I would make the case that many of them *can* be measured with minimal intrusion and time demand on the docs. Some, like experience, memory capacity, social support, coping strategies, etc. can be measured only once or can be obtained without any effort from the doc (RICHARD JOHN HOLDEN, 2005; rholden@students.wisc.edu).

Figure 1. Human factors model linking complexity to mental workload (MWL) to error.

simplification of actual processes. The many components of this model are interactive, and several are measurable during the flow of a usual work day in a primary care clinical setting. Accordingly, the complexity can be approximated by the number of coincidental problems encountered during a clinical visit and can be modified by time factors. Hence, one of the demands on a clinician can be evaluated by assessing the number of problems managed. Demands, individual factors, and work system factors also contribute to workload. Workload is translated into immediate and longer-term outcomes through a number of mediators that can be modified by control factors.

This practice-based research network study was designed to better define the relationships between number of problems per encounter, clinician workload, and perceived medical error. It was hypothesized that a positive correlation existed between the number of problems addressed and clinician workload and between clinician workload and perceived medical error. Moreover, it was proposed that a certain level of predictability existed for the number of problems encounter based on a minimal data set composed of patient age, sex, continuity status, and number of anticipated problems that the patient wishes to discuss.

OVERALL RESEARCH GOAL

The goal of this research program is to conduct a pilot study and feasibility assessment so as to inform future studies that will enhance understanding of the complex relationship between the number of problems dealt with during a clinical encounter, the workload of the clinician derived from that encounter, and the resulting likelihood of medical error during the encounter. This research was conducted in busy primary care practices affiliated with the Wisconsin Research and Education Network [WREN].

There were five principal research aims for this AHRQ-funded study:

(1) Assess the feasibility of data collection from multiple sources (e.g., patient, medical assistant, physician, medical record) for individual encounters on practice complexity.

(2) For each of 600 patient encounters, enumerate (a) patient estimated number of problems, (b) clinician workload, (c) clinician identified number of problems, (d) time spent in direct patient contact, (e) clinician estimate of likelihood of error during the encounter, and (f) patient reported adequacy to which concerns were addressed, and obtain (g) a photocopy of the clinical note for brief assessment of specific quality indicators.

(3) For the sample of clinically active active family physicians, determine the mean problem density and the mean clinician workload involved with patient encounters, and indirectly assess the propensity for medical error.

(4) Evaluate the statistical relationships that may exist between encounter problem density, clinician mental workload, and perceived medical error.

(5) Conduct an informed outlier analysis, through clinician interview and qualitative methods, to investigate outlying observations.

OVERALL NETWORK GOAL

The network goal of this program is to expand the focus (and reputation) of WREN from experience and expertise in public health, bioterrorism, and emerging infections to a much more broadly defined research agenda while enabling new WREN researchers, creating new research partnerships, and developing clinical teams at individual practices.

There were four specific WREN aims of this study:

(1) Create a new cohort of Academic Investigators—affiliated with WREN—who can combine research skills and expertise with an appreciation of the crucial role of practice-based primary care research.

(2) Enhance the role of WREN Clinician Investigators through expanding the participation of interested clinically active WREN physicians in multiple levels of the research process.

(3) Establish an innovative working relationship between WREN and researchers in Industrial Engineering at the University of Wisconsin.

(4) Involve new clinicians and incorporate medical assistants as research teams in WREN practices. This will involve expanded protocols necessitating patient recruiting and consent and other clinic-based activities.

SPECIFIC STUDY HYPOTHESES

The first three hypotheses addressed the potential associations between number of problems per encounter (NPPE), clinician workload (CWL), and perceived medical error (PME):

H1o: There is no association between NPPE and CML
H1a: A positive correlation exists between NPPE and CML

H2o: There is no association between CML and PME
H2a: A positive correlation exists between CML and PME

H3o: There is no association between NPPE and PME
H3a: A positive correlation exists between NPPE and PME

A fourth hypothesis was aimed at the predictability of encounter problem density based on a minimal data set composed of patient age, sex, and number of anticipated problems that the patient wishes to discuss:

H4o: There in no association between NPPE and patient-specific factors of age, sex, and anticipated number of medical concerns to be addressed at the visit.
H4a: A significant regression exists between the NPPE (dependent variable) and age, sex, and anticipated number of medical concerns to be addressed (independent variables).

Additional significant information on process can also be obtained from careful review of outlying observations. For this study, it was assumed *a prioi* that there would be correlations between NPPE and (CML). It was also assumed that there would be a number of outlining observations that contain significant additional information to better inform efforts in the refinement of a human factors and systems models for the reducing the tendency for medical error and enhancing the quality of care.

METHODS

Thirty-one primary care clinicians were recruited from four WREN practices. The practices included two urban and two rural settings. Each clinician was directed to collect data on 20 routine adult patient visits over a 4-week period study period. The initial target sample size was 600 clinical encounters.

Clinic days were divided into early, mid, and late morning sessions and early, mid, and late afternoon sessions. On any given day, the clinician's medical assistant selected a patient from a randomly assigned time period. The only stipulation for recruitment was that the patient be adult, not a prisoner or institutionalized, and without impairment in decision-making capacity. No other inclusion/exclusion criteria were used so as to mirror the types of patients typically seen by primary care clinicians.

Following recruitment and informed consent, basic demographic were was collected and the patient recorded the number of problems that they wanted to have addressed during that visit. Following the visit, the patient recorded to what extent their concerns were addressed. The clinician did not have access to this information at any time.

At the conclusion of the patient visit, the clinician completed instruments dealing with the visit. Clinician workload was measured using the NASA Task Load Index (NASA-TLX); the number and types of problems addressed were recorded; and the extent to which patient concerns were addressed as well as physician estimated likelihood of possible omission and/or error were recorded on 7-point Likert scales.

The NASA-TLX is a weighted combination of six dimensions of work, including mental demand, physical demand, time demand, performance, effort, and frustration level, that reliably measures workload. Moreover, this is a validated and commonly used instrument in human factors engineering. Whereas the NASA-TLX has had some use in healthcare workers [4], it has not been previously utilized in primary care settings.

A copy of the corresponding clinical encounter note was de-identified, labeled with the clinician ID and the encounter number, and attached with the study forms. The clinical note was assessed for quality indicators around blood pressure and tobacco use.

The unit of analysis was the clinical encounter. Relationships between the number of problems per encounter (NPPE), clinician workload (CWL), and perceived medical error (PME) were assessed using Pearson correlation and least squares linear regression. Differences among clinicians were assessed using chi-squared, analysis of variance, and analysis of covariance, when appropriate.

Data from individual clinicians were assessed for the relationship between NPPE and MWL using ordinary least squares regression. Outlying events were identified as those with an absolute standardized residual of 2.0 or greater, thus indicating a great or less MWL than expected for the number of problems. In addition, occasional "interesting" events that were significantly displaced from the regression line but did not meet the definition of an outlier were identified from graphical plots.

Following identification, the de-identified clinical note was faxed to the event encounter clinician for review, and a brief interview was conducted in person or by phone. Interviews were conducted only on visits that were clearly remembered by the clinician. Open-ended questions were asked pertaining to anything that stood out about the visit, factors that may have contributed to a greater or lesser MWL, the relationship between the clinician and the patient, and contributing factors of clinic setting or schedule.

The interviewers kept notes regarding the salient points of the interview. The texts were typed and provided to three reviewers for assessment and identification of themes associated with high and low mental workloads. The final list of factors was constructed following joint review of each case and development of consensus.

RESULTS

<u>Patient population.</u> Data were collected from 615 patient encounters conducted by 31 study clinicians (mean=19.8 encounters per clinician). Data from six visits were discarded due to inclusion criteria violations (patients younger than 18 years at the time of visit). Data collection occurred from August 2007 through March 2008.

Temporal Distribution of Encounters

(biased by time and day; X^2=32.4; P=0.039)

	Mon	Tue	Wed	Thu	Fri	
Early AM	12	19	12	21	17	**81**
Mid AM	11	17	26	21	23	**98**
Late AM	14	18	23	28	12	**95**
Early PM	16	9	13	11	8	**57**
Mid PM	25	29	18	22	14	**108**
Late PM	22	21	12	12	11	**78**
	100	**113**	**104**	**115**	**85**	**517**

Figure 2. Temporal distribution of study encounters. Shading indicates relative frequency. Numbers vary slightly from text due to missing data.

Study visits occurred more commonly on Tuesdays (n=136) than expected and less commonly on Fridays (n=89) than expected (X^2=10.336; d.f.=4; P=0.0147). Early afternoon visits were under-represented (n=59) and mid-afternoon visits were over-represented (n=109) in the final sample (X^2=18.046; d.f.=5; P=0.0005). Overall, however, there was good representation of encounters in each of 30 potential time slots (Figure 2).

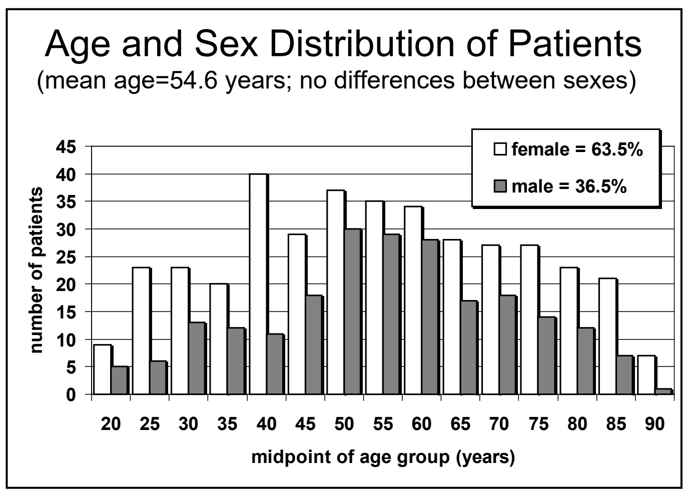


Figure 3. Demographics of consented study patients.

Encounters with female patients represented 63.5% of the final sample. Patient ages ranged from 18 to 90 years, with a median age of 55 years and an average age of 54.6 ±17.5 (sd) years. There were no significant differences in the mean ages among male and female patients (Figure 3). These summary statistics compared favorably with those derived from the University of Wisconsin, Department of Family Medicine's Clinical Data Warehouse for July 2007 through June 2008. The average age of adult patients, based on 281,982 primary care visits in the data warehouse, was 48.8 years; 60.4% of adult primary care patients were women.

Most clinical encounters were with the patient's continuity clinician (84.0%). The presenting problems for the clinical encounters were evenly split between acute (43.8%) and chronic (44.8%) medical conditions. Well and health maintenance visits represented an additional 9.7%. The average scheduled visit length was 21.2 minutes.

Clinician population. 32 clinicians were recruited and consented for participation in this study. One clinician dropped out prior to the start of data collection. The remaining 31 clinicians practice at four WREN-affiliated primary care clinics. Three of the clinics were located in Wisconsin; the fourth was located in Iowa. Two sites were urban (with 51.6% of clinicians); two were rural (48.4%). Both urban practices were actively utilizing electronic medical record systems. Physicians, physician assistants and nurse practitioners were included in the study, representing family medicine and internal medicine practices (see Table 1). Most participants were engaged in full-time practice, and the clinicians tended to be quite experienced. On average, 15.5 years had elapsed since completion of training (median=14 years; range=1 to 32 years), and they been practicing at their current clinical sites for an average of 12.9 years (median=14 years; range=1 to 28 years).

Table 1. Demographics of Study Clinicians		
Descriptor	**Number**	**Percent**
Clinician		
MD/DO	24	77.4
NP/PA	7	22.6
Type of Practice		
Family Medicine	22	71.0
Internal Medicine	9	29.0
Percent of Time in Clinical Care		
1-3 half days per week	1	3.2
1-3 half days per week	4	12.9
1-3 half days per week	26	83.9
Setting		
Rural	15	48.4
Urban	16	51.6
EMR in Use		
Yes	16	51.6
No	15	48.4

Number of Problems per Encounter. At the time of rooming and before any contact with the study clinicians, patients identified the number of problems that they wanted to have addressed during the forthcoming encounter. Patients identified from 1 to 10 problems. The mean number of patient-reported problems was 2.32$\pm$1.42 (sd) (Figure 4).

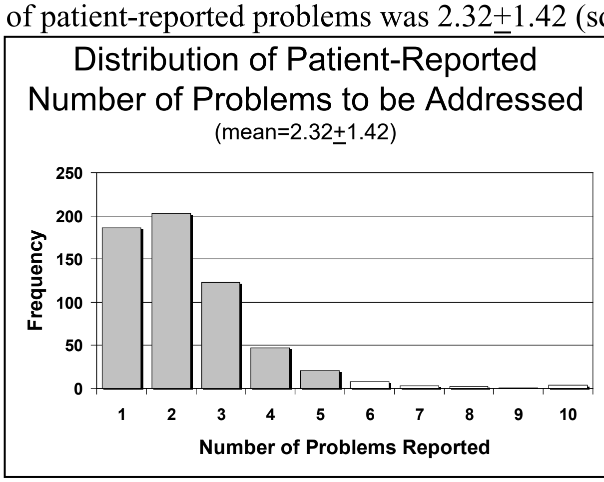


Figure 4. Number of patient-identified problems at the beginning of clinical encounters

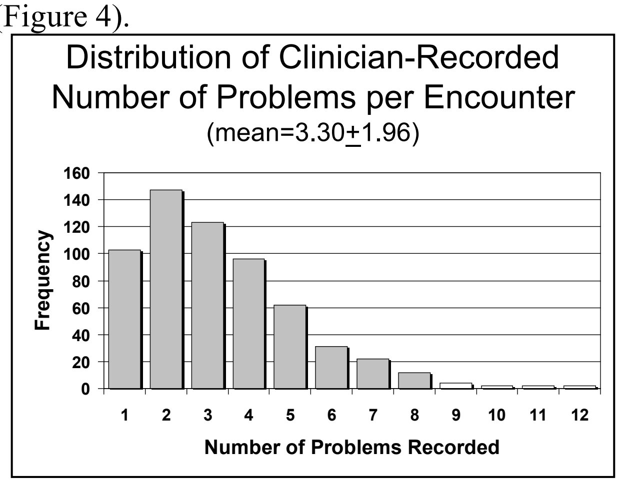


Figure 5. Number of clinician-identified problems at the conclusion of clinical encounters

Clinicians reported evaluating and managing from 1 to 12 problems during each encounter, with an average number of problems per encounter of 3.30+1.96 (sd) and a median of 3 (Figure 5). Significant differences existed, however, among the 31 clinicians in terms of mean NPPE (ANOVA; $F_{[30,575]}$ =7.50; P<0.001). The clinician-specific range of mean NPPE was 1.72 to 5.76 problems per encounter (Figure 6).

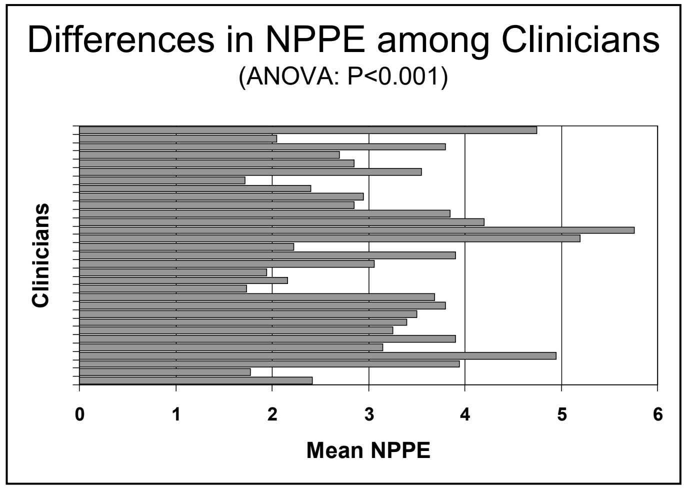


Figure 6. Mean number of problems per encounter (NPPE) for each of 31 primary care clinicians

There was a moderate positive correlation between patient-identified and clinician-reported problems (r=0.446; P<0.001) (Figure 7). In addition, NPPE was associated with the age of the patient (r=0.237; P<0.001) and the continuity status of the patient (ANOVA: $F_{[1,534]}$ =24.83; P<0.001). The patient's sex did not affect NPPE. On average, clinicians identified 1.14 more problems for continuity patients than for non-continuity patients. The mean encounter problem density was 10.32+6.89 (sd) problems evaluated and managed per hour of scheduled clinic time.

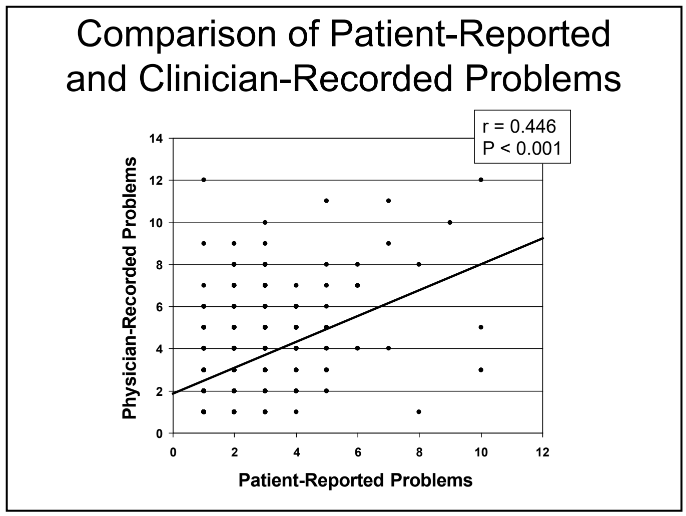


Figure 7. Comparison of the number patient-identified and clinician-identified problems

The number of problems per encounter (NPPE) was significantly related to the number of patient-identified problems (NPIP), age of patient, and continuity status of the patient in a multivariate model (r^2=0.246; P<0.001):

$$NPPE = 0.440 + 0.576(NPIP) + 0.0183(Age) + 0.602(Continuity).$$

Although these three pre-visit parameters were associated with NPPE, the patient's sex was not.

Task Load of Primary Patient Care. The NASA task load index (NASA-TLX) performed well in the primary care clinical setting, taking about 30-45 seconds to complete. A wide range of values of the composite TLX emerged in usual clinical care, extending from 5.0 to 95.3. The low score visit was for a 23-year old female continuity patient presenting with a single problem of chronic back pain in a 30-minute visit. The high score visit occurred for a 74 year-old female continuity patient presenting with acute chest pain, hypertension, hyperlipidemia, urinary frequency, microscopic hematuria, allergic rhinitis, a forehead skin lesion, finger muscle spasms, dry skin, and word finding difficulties within a 20-minute visit.

The mean NASA-TLX score for all visits was 47.6±18.4 (sd), with a median value of 49.3, indicating a moderate task load for routine clinical work. The distribution of 598 composite TLX scores approximated a normal distribution (Figure 8).

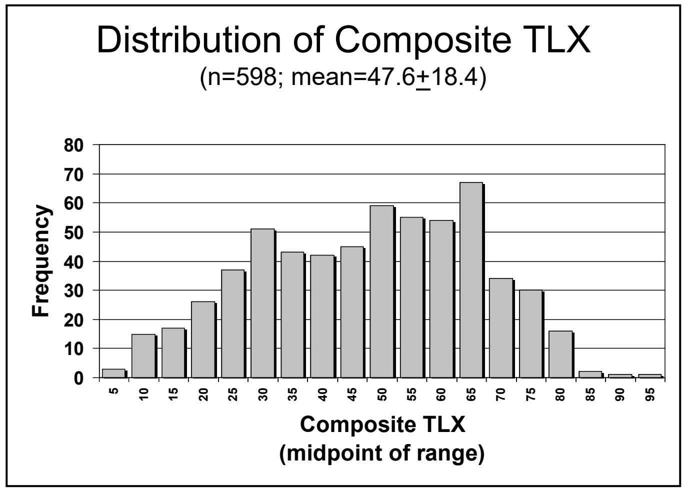


Figure 8. Distribution of NASA-TLX composite scores in ambulatory primary care practice.

Determinants of Task Load in Primary Care. Significant differences were found in the means and distributions of the six domains comprising the NASA TLX (Kruskal-Wallis: H=1176.3; df =5; P<0.001). The two largest components of workload were time demand (TD: 11.74 ± 8.98 [mean ± sd]) and mental demand (MD: 11.68 ± 8.24), each contributing, on average, 25% of total workload. Effort (E: 10.66±6.74) contributed 22%, while performance (P: 5.94±5.03) and frustration (F: 6.10±7.50) contributed 13 and 11%, respectively. Physical demand (PD: 1.53±3.27) was the smallest contributor to workload representing only 4% (Figure 9). The distributions of each of the six domains are illustrated in Figures 10-15 to allow graphical and visual comparison. Of note is the extreme skewness of physical demand (low physical demand predominates), performance (good performance predominates), and frustration (low frustration predominates). Mental demand, time demand, and effort demonstrated much broader distributions of values.

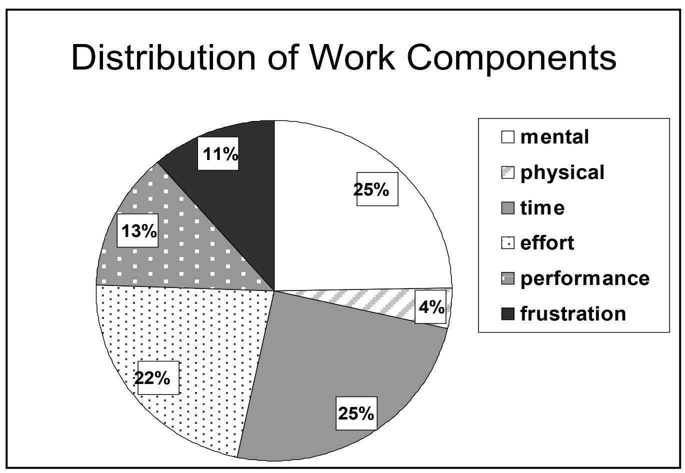


Figure 9. Relative contributions of individual NASA-TLX domains to the composite score

Principal component factor analysis with varimax rotation was conducted to assess relationships among the six domains when applied to primary care practice. Six independent factors emerged.

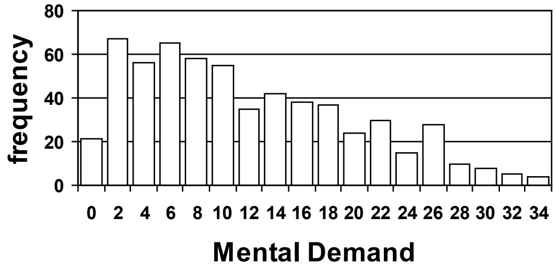


Figure 10. Distribution of mental demand

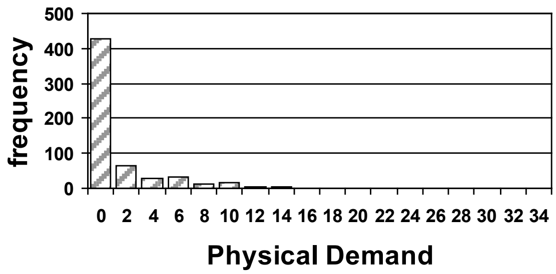


Figure 11. Distribution of physical demand

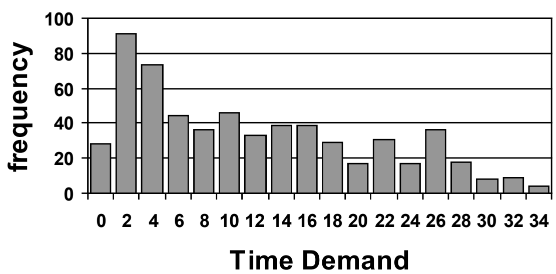


Figure 12. Distribution of time demand

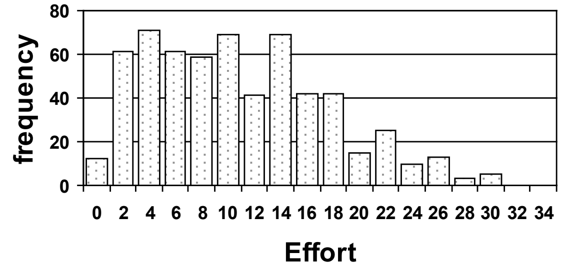


Figure 13. Distribution of effort

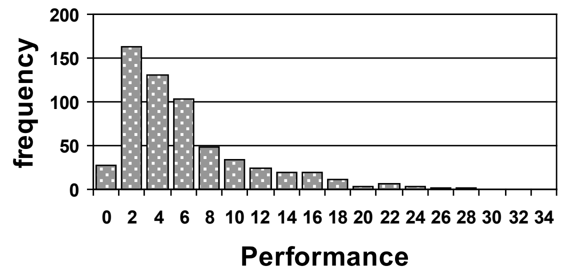


Figure 14. Distribution of performance

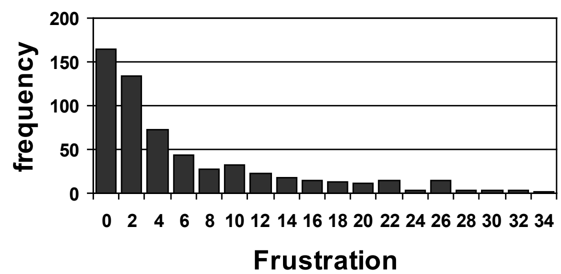


Figure 15. Distribution of frustration

Each factor had a high loading for one original NASA-TLX domain (Figure 16).

Significant differences existed among the 31 clinicians in terms of mean NASA-TLX scores (ANOVA; $F_{[30,567]}$ =13.20; P<0.001). The clinician-specific range of mean NASA-TLX was from 18.7 to 65.8 (Figure 16). The task load was also related to day of the week, with Mondays and Tuesdays having significantly lower scores (44.1) and Wednesdays through Fridays having higher scores (50.4) (ANOVA; F[1,571] =17.04; P<0.001) (Figure 18). The time of day did not have an effect on the task load.

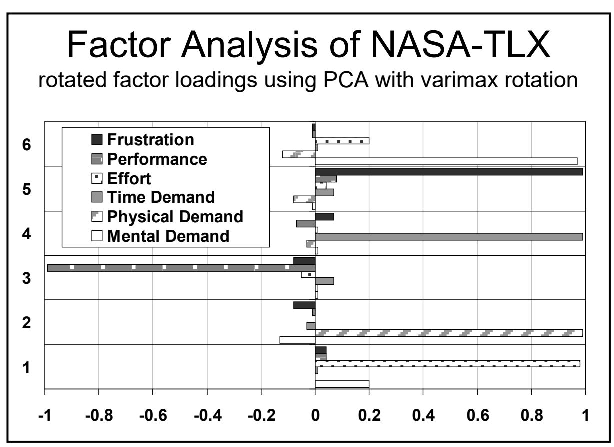


Figure 16. Factor analysis of NASA-TLX

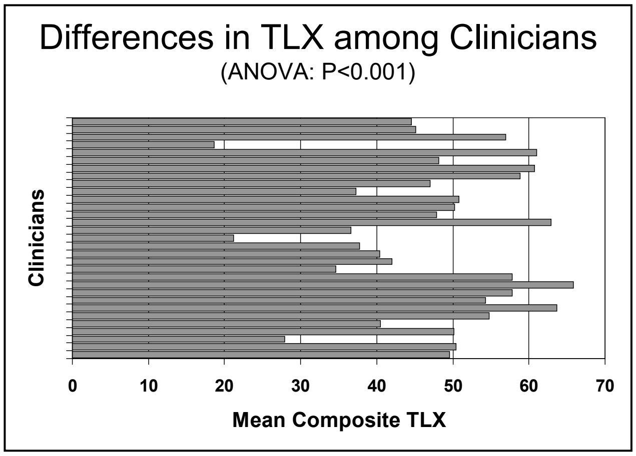


Figure 17. Mean composite TLX score for each of 31 primary care clinicians

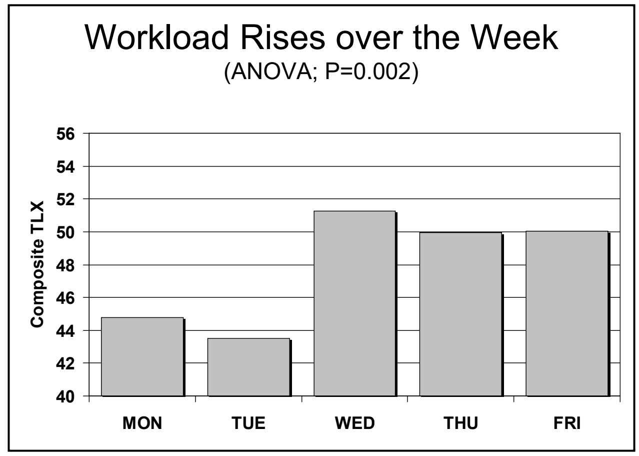


Figure 18. Mean composite TLX based on day of the week

Continuity status and chronicity of the presenting problem contributed to the task load. Encounters attended by a continuity clinician were associated with a significantly higher task load than those for which there was no continuity (48.7 vs. 43.8; ANOVA: $F_{[1,496]}$ =6.31; P=0.023). Acute presenting problems were associated with significantly lower task loads than were chronic presenting problems (44.1 vs. 51.2; ANOVA: $F_{[1,521]}$ =7.10; P<0.00). The sex of the patient had no effect on the task load.

Relating Number of Problems to Task Load. The NASA-TLX reported for a visit was significantly related to NPPE (Figure 19). For each additional problem reported for an encounter, the NASA-TLX score increased by 3.45 (r^2=0.134; P<0.001). The average encounter with 3.3 problems resulted in an estimated task load score of 47.7. Therefore, for each additional problem, the workload increased by an estimated 7.2%. Of note, no differences in the slopes of the linear relationships between NASA-TLX and NPPE were found among individual clinicians using ANCOVA, indicating robustness of this relationship.

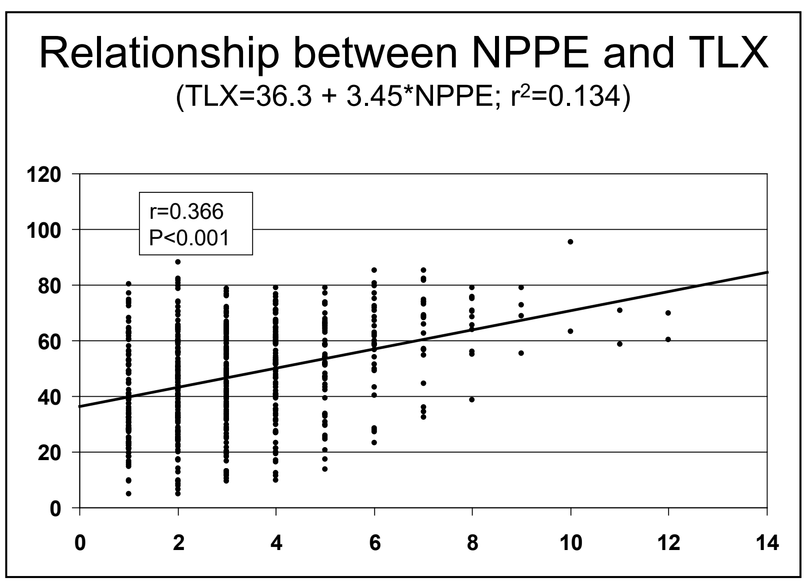


Figure 19. Relationship between NPPE and workload

Workload increased for all physicians as the NPPE increased. Accounting for individual differences in the intercepts of the linear relationships in the ANCOVA model, however, yielded a significantly strong relationship relating the NASA-TLX to NPPE with a slope of 4.09 (r^2=0.547; P<0.001).

<u>Perceived Medical Error.</u> The mean reported perceived medical error (PME) was 6.87 $\pm$2.25 (sd), with a median of 7 and a range of 4 to 16 on a 4- to 28-point scale (Figure 20). Significant differences existed among the clinicians in terms of mean reported PME (ANOVA; $F_{[30,562]}$ =23.31; P<0.001). Mean scores for individual clinicians ranged from 4.25 to 10.26 (Figure 21).

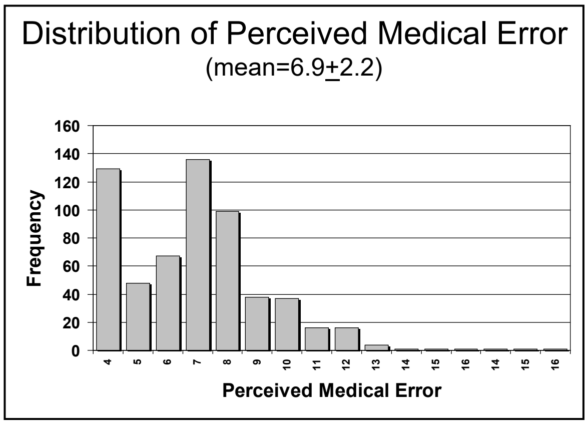


Figure 20. Distribution of PME scores in ambulatory primary care practice

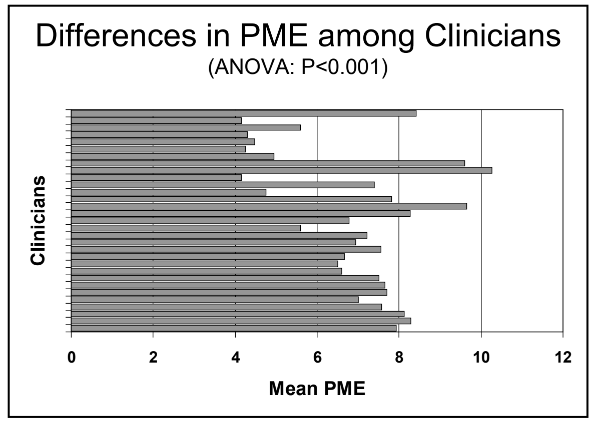


Figure 21. Mean PME score for each of 31 primary care clinicians

There was a significant, but small, positive relationship between the NASA-TLX score and the PME (Figure 22; r^2=0.044; P<0.001). Of note, only two of 31 clinicians had significantly different slopes of the linear relationship between PME and TLX using ANCOVA, indicating robustness of this relationship. Accounting for individual differences in the intercepts of the linear relationships in the ANCOVA model yielded a significantly strong relationship relating PME to the TLX with a slope of 0.028 (r^2=0.591; P<0.001). An encounter with the mean TLX of 47.6 would have a resulting PME of 7.92. Consequently, a 10-point rise in NASA-TLX would be associated with an estimated 3.5% increase in the PME score.

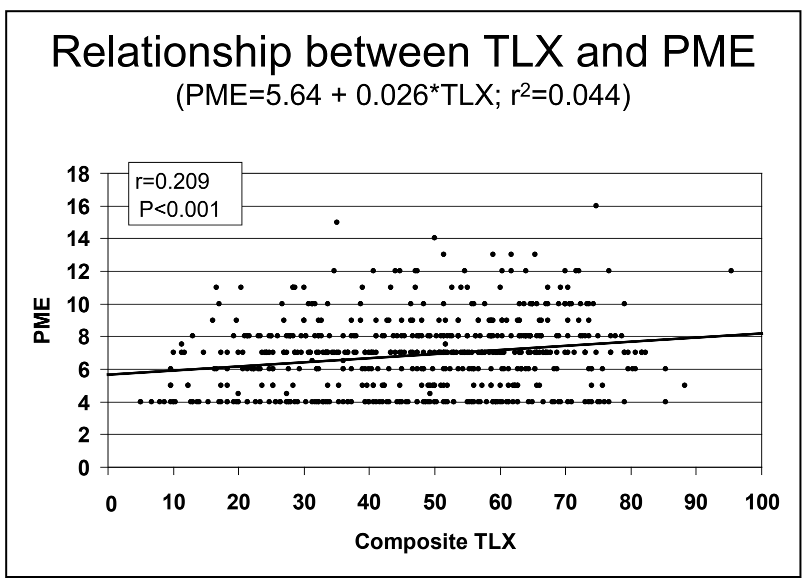


Figure 22. Relationship between workload and PME

Outlier Analysis. Brief interviews with study clinicians regarding encounters with higher than expected and lower than expected NASA-TLX scores based on NPPE provided valuable insights into unmeasured factors that affect clinical practice. Themes of relationship with problem expectation, adjustment of time factors through clinic scheduling, encounter outcome, patient-clinician relationship, and the perceived motivations for the clinical encounter emerged as dominant themes (see Table II).

Table II. Emergent Themes for Outlier Analysis of Clinical Visits with Lower and Higher than Expected Workload

Lower than Expected Workload	Higher than Expected Workload
● straightforward problem ● adequate time ● clinician knows patient well ● encounter had good outcome ● patient satisfied ● lack of major problems ● management clear (standard care plan) ● patient not demanding	● unexpected problems and needs ● being behind, insufficient time ● patient is not known to clinician ● unhappiness or conflict in encounter ● discordant relationship ● unclear decision making, unclear what to do ● demanding, questioning, worked up, high maintenance, nonresponsive patient

Achievement of Research and Network Aims. The five research aims for this AHRQ-funded study were successfully achieved. We were able to demonstrate feasibility of data collection from multiple sources (e.g., patient, medical assistant, physician, medical record) for 609 individual encounters on practice complexity. All pre-specified data elements were except for the time spent in direct patient contact. This factor was determined to be too difficult to collect accurately within the context of funding constraints and busy clinical practices. Also, scheduled time was found to be a better descriptor than actual time during pilot testing. The clinician specific parameters were established for each of the 31 participating clinicians, and individual feedback was provided at post-study site visits. Finally, statistical relationships between encounter problem density, clinician workload, and perceived medical error were evaluated, and an informed outlier analysis was successfully completed.

The network goal was attained, thus expanding WREN's focus while enabling new WREN researchers, creating new research partnerships, and developing clinical teams at individual practices. The four network aims also were achieved. We were able to involve new cohort of academic investigators in a PBRN project. WREN Clinician Investigators were essential for the success of this study at the four clinical sites. An ongoing working relationship between WREN and researchers in Industrial Engineering was enhanced and is continuing. Finally, we were able to involve new clinicians and incorporate medical assistants as research teams in WREN practices.

DISCUSSION AND CONCLUSIONS

Primary care clinical practice has a moderately high workload with a high degree of variation. Different clinicians experience different mean levels of workload. It is not surprising that CWL is directly related to the complexity of the patient visit, here defined by the simple parameter of number of problems. This is intuitive to the practicing clinician. What is surprising is the high level of concordance in the relationship between NPPE and CWL among 31 clinicians practicing in a variety of settings. Accounting for NPPE and individual differences explains 54.7% of the total variance in the NASA-TLX scores. Accordingly, CWL experienced in the clinical encounter increases as the complexity of the visit increases.

On average, primary care clinicians manage 3.3 problems during each encounter. This estimate is significantly higher than a previous estimate made using similar methods [3]. It is possible that changes in practice and patients have resulted in increasing number of problems dealt with during routine care. NPPE can be quite variable, ranging from 1 to 12 problems. Furthermore, primary care clinicians evaluate and manage problems at a rate of over 10 per hour of scheduled clinic time. NPPE is somewhat predictable, however, based on the age of the patient, continuity status of the patient, and number of patient identified problems. Such predictability offers the possibility *a priori* clinical schedule modification to accommodate “difficult” or “simple” patient visits.

As workload rises, there is a concomitant increase in the likelihood of medical error. This study was limited by clinician self-assessment of the likelihood of error. Hence, there is no ability to detect the presence of actual error. This vague parameter can guide future research but says little about the nature or seriousness of the error.

Comment is needed on those unmeasured factors that—though outlier analysis—emerged as potentially important in affecting the CWL. The listings, as presented in Table 2, underscore what all clinicians inherently know: the relationship with a patient is a highly important factor in determining both patient and clinician outcome. Factors associated with higher than expected workload included discordant relationships, insufficient time, conflict, and unsolvable problems. Such results tend to underscore previous descriptions in the literature of the “difficult” or “heartsink” patient. [5-8]

Time and complexity has been best studied in hospital settings. An early effort related illness severity, dependency, complexity of care, and time to nursing intensity [9]. More recently, an analysis conducted in 18 Canadian hospitals demonstrated a correlation between patient complexity and use of nursing resources [10]. In primary care practices, time spent during an encounter varies with visit type [11] and sex of patient [12]. Appropriate preventive services are often left out. For example, a small, but revealing study by Rafferty [13] used work sampling techniques and 4,563 observations to describe the components of care during 2,826 patient visits. Of time spent in patient-related activity, clinicians utilized 89.4% for diagnosis, management, and treatment and 10.6% for screening and prevention.

Complexity and time factors can conspire to produce medical error and reduce quality of care. A recent AHRQ study estimates that up to 15% of hospital stays in 2000, valued at $26.5 billion, could have been prevented with high-quality primary and preventive care [14]. In primary care, medical errors relate primarily to communication problems, diagnostic tests, and medications [15-17] and have been reported in up to 24% of outpatient visits [18]. Nevertheless, only 1% of studies dealing with medical error and the role of time factors in medical error involve the primary care setting.

Complexity, based on the problems of a patient and the time in which to evaluate and manage them, can be a significant cause of medical error, both in commission and omission. High levels of information in intensive care units are associated with error [19]. Addition of nursing staff, even those without ICU training, into intensive care settings improves the quality of patient care primarily due to the increase in available nursing time [20]. Significant differences exist, however, between the hospital and ICU setting and the ambulatory setting of primary care. The problems of hospitalized patient are often known in advance, and time flexibility exists to accommodate these problems. Primary care practice often lacks the anticipation of the patient's agenda and care is tightly scheduled into a compartmentalized workday.

Not surprisingly, relationships between time and quality have been demonstrated in primary care settings as well. The strongest predictor of recall of behavioral advice in a direct observation study was the duration of advice [21]. Patient satisfaction and lower rates of medication prescribing have been associated with longer visit time [22]. Furthermore, short outpatient visits with high efficiency are associated with poor communication and patient dissatisfaction [23].

Human factors and systems engineering offers a radical change from which the medical system is evaluated compared to systems of peer review by other clinicians. These approaches focus on separating human factors from system factors and provide the ability to understand and prevent errors at the systems level [24-26]. Two recent studies demonstrate to potential roles of systemic changes in decreasing error and improving quality. The limitation of medical residents to 16 consecutive work hours significantly reduced errors in a medical intensive care unit setting [27]. The availability of fully implemented electronic medical record systems in primary care settings was associated with a 60% reduction in reports of missing records [28].

In this study, we attempted to dissect components of primary care complexity in a causal chain from a human factors engineering perspective. The number of problems in a visit affects the clinician's workload. Workload may contribute to error. Further study of this is warranted to better define relationships identify interventions that can reduce workload and medical error.

LITERATURE CITED

1. Stange KC, Zyzanski SJ, Jaen CR, et al. Illuminating the 'black box'. A description of 4454 patient visits to 138 family physicians. J Fam Pract 1998; 46(5):377-89.

2. ACGME. Program Requirements for Residency Education in Family Practice. Approved 9/26/00; Effective July1, 2001. http://www.acgme.org (accessed on 4/17/03).

3. Beasley JW, Hankey TH, Erickson R, et al. How many problems do family physicians manage at each encounter? a WReN study. Ann Fam Med 2004; 2:405-10.

4. Young G, Zavelina L, Hooper V. Assessment of workload using NASA Task Load Index in perianesthesia nursing. J Perianesth Nurs. 2008; 23(2):102-10.

5. O'Dowd TC. Five years of heartsink patients in general practice. BMJ. 1988 August 20; 297(6647): 528–530.

6. Mathers N, Jones N, Hannay D. Heartsink patients: a study of their general practitioners. Br J Gen Pract. 1995 June; 45(395): 293–296.

7. McDonald PS, O'Dowd TC. The heartsink patient: a preliminary study. Family Practice 1991; 8:112-116.

8. Jackson JL, Kroenke K. Difficult patient encounters in the ambulatory clinic : clinical predictors and outcomes. Arch Intern Med. 1999; 159:1069-1075.

9. Prescott PA, Ryan JW, Soeken KL, Castorr AH, Thompson KO, Phillips CY. The Patient Intensity for Nursing Index: a validity assessment. Research in Nursing & Health 1991; 14(3):213-21.

10. McGillis Hall L, Doran D, Pink GH. Nurse staffing models, nursing hours, and patient safety outcomes. J Nurs Admin 2004; 34(1):41-5.

11. Yawn B, Goodwin MA, Zyzanski SJ, Stange KC. Time use during acute and chronic illness visits to a family physician. Fam Practi 2003; 20(4):474-7.

12. Tabenkin H, Goodwin MA, Zyzanski SJ, et al. Gender differences in time spent during direct observation of doctor-patient encounters. J Women's Health 2004; 13(3):341-9.

13. Rafferty M. Prevention services in primary care: taking time, setting priorities. West J Med 1998; 169:269-75.

14. AHRQ, HCUP Fact book No. 5, Preventable Hospitalizations: a window into primary and preventive care, 2000, factbook. http://www.ahrq.gov/data/hcup/factbk5/ accesses 2/1/05)

15. Kuzel AJ, Woolf SH, Gilchrist VJ, et al. Patient reports of preventable problems and harms in primary health care. Ann Fam Med 2004;

16. Fernald DH, Pace WD, Harris DM, et al. Event reporting to a primary care patient safety reporting system: a report from the ASIPS collaborative. Ann Fam Med 2003; 2(4):327-32.

17. Rubin G, George A, Chinn DJ, Richardson C. Errors in general practice: development of an error classification and pilot study of a method for detecting errors. Quality & Safety in Health Care 2003; 12(6):443-7.

18. Elder NC, Vonder Meulen M, Cassedy A. The identification of medical errors by family physicians during outpatient visits. Ann Fam Med 2004; 2(2):125-9.

19. Donchin Y, Seagull FJ. The hostile environment of the intensive care unit. Current Opinion in Critical Care 2002; 8(4):316-20.

20. Binnekade JM, Vroom MB, de Mol BA, de Haan RJ. The quality of Intensive Care nursing before, during, and after the introduction of nurses without ICU-training. Heart & Lung 2003; 32(3):190-6.

21. Flocke SA, Stange KC. Direct observation and patient recall of health behavior advice. Prev Med 2004; 38(3):343-9.

22. Dugdale DC, Epstein R, Pantilat SZ. Time and the patient-physician relationship. Am J Int Med 1999; 14(suppl 1):S34-40.

23. Goedhuys J., Rethans JJ. On the relationship between the efficiency and the quality of the consultation. A validity study. Fam Pract 2001; 18(6):592-6.

24. Rogerson WT Jr, Tremethick MJ. Turning the tide on medical errors in intensive care units: a human factors approach. Dimensions of Critical Care Nursing 2004; 23(4):169-75.

21. Hart GK. Error in medicine: adverse events in intensive care. Journal Suisse de Medecine 1999; 129:1583-91.

25. Horak BJ. Welton W. Shortell S. Crossing the quality chasm: implications for health services administration education. J Health Admin Ed 2004; 21(1):15-38.

26. Landrigan CP, Rothschild JM, Cronin JW, et al. Effect of reducing interns' work hours on serious medical errors in intensive care units. NEJM 2004; 351(18):1838-48.

27. Smith PC, Araya-Guerra R, Bubiltz C, Parnes B, Dickinson LM, Van Vorst R, Westfall JM, Pace WD. Missing clinical information during primary care visits. JAMA 2005; 293:565-71.