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Exploration of Information Technology Related Barriers Affecting Rural Primary Care Clinics

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ABSTRACT

With an aim to improve rural healthcare, Oklahoma State University (OSU) Center for Health Systems Innovation (CHSI) conducted a study with primary care clinics (N=35) in rural Oklahoma to identify possible impediments to clinic workflows. The study entailed semi-structured personal interviews (N=241) and administered an online survey using an iPad (N=190). Respondents encompassed all consenting clinic constituents (physicians, nurses, practice managers, schedulers). Quantitative data from surveys revealed that electronic medical records (EMRs) are well accepted and contributed to increasing workflow efficiency. However, the qualitative data from interviews reveals that there are IT-related barriers like Internet connectivity, hardware problems, and inefficiencies in information system platforms. Interview responses identified six IT-related response categories (computer, connectivity, EMR-related, fax, paperwork, and phone calls) that routinely affect clinic workflow. These categories together account for more than 50% of all the routine workflow-related problems faced by the clinics. Text mining was performed on transcribed Interviews using SAS Text Miner to validate these six categories and to further identify concept linking for a quantifiable insight. Two variables Redundancy Reduction and Idle Time Generation are derived from survey questions with low scores of 545 and 513 respectively out of 960. Finally, ANOVA was run using SAS Enterprise Guide 6.1 to determine whether the six qualitative categories affect the two quantitative variables differently.

INTRODUCTION

Past studies have explored various topics related to EMR implementation, adoption, its success/failure, and benefits. The Agency for Healthcare Research and Quality summarizes that, though 95 percent of critical access hospitals (CAHs) have computerized their administrative functions (e.g., claims submission, billing, accounting, payroll, and/or patient registration), only 21 percent utilize some form of an EHR. Center for Rural Affairs, Nebraska points out that increased dependence on technology has led to workflow related barriers and reduced productivity.[1] Brian E. Whitacre and Randi S. William indicated in their work, “Electronic Medical Record Adoption in Oklahoma Practices: Rural–Urban Differences and the Role of Broadband Availability”, state that overall EMR adoption rates in rural and urban practices are quite similar, however there are significant differences among specific subcategories, including the absence of statistical relationship between EMR adoption and measures of broadband availability. Additionally, they concluded that specific factors need to be explored that may have an impact on the EMR adoption in rural healthcare in Oklahoma.[2]

This study takes a step back from here and attempts to explore Information Technology related barriers affecting routine workflow at primary care clinics, specifically in rural Oklahoma. In addition to EMR inefficiencies, workflow problems in rural areas can arise from computer hardware, software, telecommunication systems, and lack of expertise/training and/or reliable technical support availability. Furthermore, these components form an integral continuum of technology and automated systems utilized in rural healthcare delivery. The OSU, Center for Health Systems Innovation (CHSI), focus on rural primary care, as the entry point of care and a critical aspect of Oklahoma’s rural healthcare system, led our team to utilize their state-wide survey data to generate insights related to this topic.

CHSI designed this study to understand workflow related barriers and create tailored solutions for the financially and operationally ailing rural primary care clinics (N=35) in Oklahoma. Utilizing a mixed methods approach, factors that commonly interfere with rural primary care workflow were sought out. Fieldwork entailed conducting personal semi-structured interviews, audiotaped on an iPad® (N=241),

administering an online survey using an iPad® (N=192), collecting layout maps and classification surveys per site. Respondents included all clinic constituents such as doctors, nurses, practice managers, schedulers, etc., at each site. Survey question (Q=29) responses varied but generally held a Likert 5 point scale or polar format. According to the types of questions asked, denotations of answer options were as follows: Strongly Agree – Strongly Disagree, Yes/No, All the time – Never, Very Efficient – Very Inefficient, coded numerically from 1 to 5. Utilizing domain expertise and an interdisciplinary team, the survey questions (Q=29) were categorized into ***10 fields***: Electronic medical record, Employee management, Communication, Error elimination, Patient experience, Known patient management challenges, Redundancy reduction, People and material uniformity, Tasks without interruption, and Staff rating of overall efficiency. The items within these categories are the basis of this study. Interview questions (Q=9) were designed to identify barriers to workflow efficiency that could impact patient satisfaction, profitability, and productivity of rural clinics. An example is, "What 3 to 5 factors cause delays in your daily work routine", Recorded responses (N=241) were transcribed for further qualitative analysis that resulted in identification of ***six Information Technology related response categories***: Computer, Connectivity, EMR related, Fax, Paperwork, and Phone calls, all of which affect clinical workflow on a routine basis.

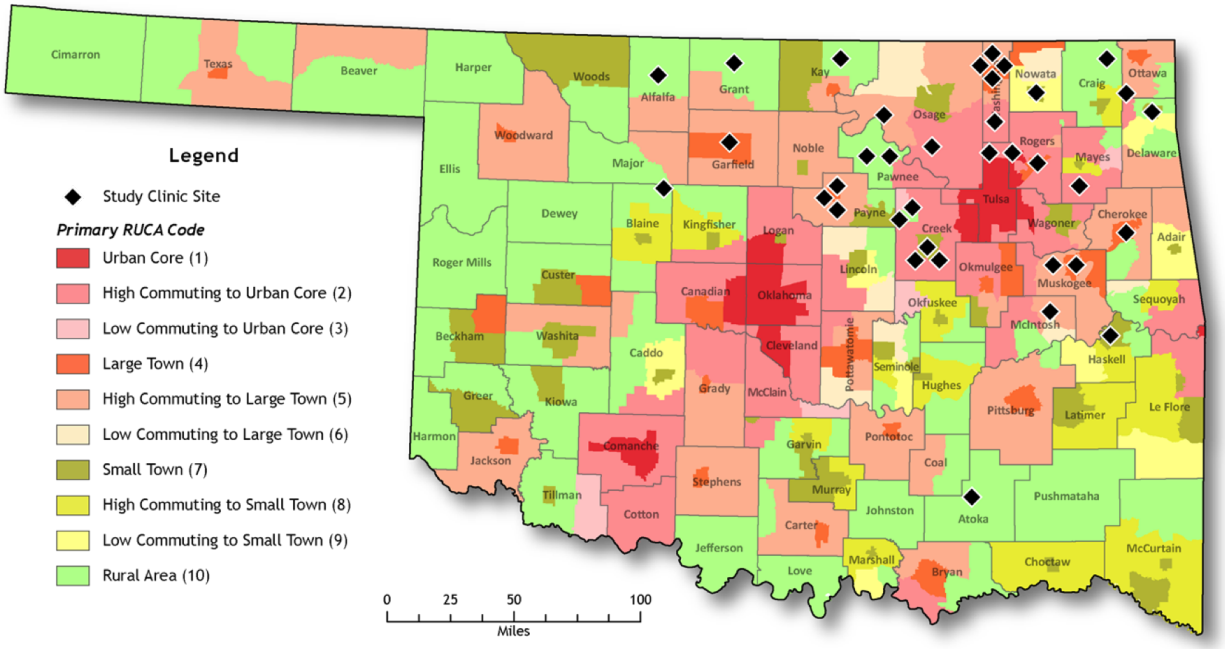


Figure 1: Oklahoma Map showing the 36 Clinic Sites

(Note: 1 site excluded from study)

Survey data indicates that EMRs are well accepted and contribute to increasing workflow efficiency, however the qualitative data analysis from interviews unfolds that there are many instances where EMR and redundant paperwork (possibly due to low adoption of EMR or inefficient EMR systems) form a part of routinely faced problems. Several other IT related barriers like Internet connectivity, hardware problems also frequently create workflow barriers. Consequently, results from qualitative interview and quantitative survey is combined for our statistical analysis, to identify if the means of six categorical IT related categories differ significantly within "Redundancy" and "Idle Time" domain survey scores.

DATA PREPARATION

The 'scored dataset' from questionnaire and 'transcribed dataset' from interviews, is used to prepare the final dataset for the analysis. The questionnaire response dataset has scores for each 29 questions out of a perfect total score of **960**, grouped into 10 categories. *Table 1* underlines an illustration of areas and

their perception based on the scores given by the providers, nurses and other clinic constituents. These scores help us give a generic idea about the workflow perceptions across the ten categories. For example, perception attributes of "**Electronic Medical Records"** received high scores, however questions pertaining to **"Redundancy Reduction"** and **"Idle time Generation"** were comparatively low on scores. Certainly, there are factors that are contributing in workflow inefficiencies, in spite of the fact, that EMR is perceived to be contributing positively to the efficiency. This flip side was noticed and triggered the further analysis to find the possible explanations of these low scores with the help of the open-ended responses gathered from the interviews.

Categories	Questions	Total Score
Electronic medical record	6_How beneficial it is Electronic Medical Record (EMR) or Electronic Health Record (EHR)?	866
	7_How efficient is (or would be) an EMR or EHR to your practice?	777
Employee management	1_The established policies and procedures are practical for daily use in the clinic.	797
	12_Your role responsibilities are explicitly defined and are in line with your actual day-to-day activities.	776
	23_You feel that your time, energy, and expertise are utilized efficiently to contribute to the quality of healthcare in the clinic?	776
Patient experience	2_How comfortable do you believe patients feel in your practice?	544
	3_Do you believe your patients are likely to return?	899
	4_How inviting is your waiting room area?	744
	13_Patient satisfaction surveys are consistently administered, evaluated and action is taken based on survey outcomes.	656
	28_The clinic accepts and works in all walk-ins.	710
Overall efficiency	24_Overall, the clinic workflow in our clinic seems organized and efficient.	744
Communication	14_Communication within the clinic and between other providers is usually standard, straightforward and does not entail any loss of information or misunderstandings.	698
Error elimination	22_There are times when work contains errors, requires rework, has mistakes, or lacks something necessary?	696
Known patient management challenges	11_Sometimes you get the impression that patients visit the practice more to socialize than for specific health reasons.	519
	25_When there are many patients in the clinic, the clinic functions efficiently and effectively without disruption or chaos.	692
	26_We have patients that return with recurrent (non-chronic) issues for which they were previously treated.	444
	27_Patients with appointments that do not show up for their appointment affect clinic efficiency and flow?	431
	29_Walk-ins disrupt the workflow in the clinic?	517
People and material uniformity	15_There are occasions when idle time is created or time is wasted, pertaining to one activity, when material, information, people or equipment are not ready?	513
	20_There are more supplies on hand at the clinic than are needed right now or required to do the work (e.g., medications, supplies in rooms/departments, etc.)?	648
	21_There are fewer supplies on hand at the clinic than are needed right now or required to do the work (e.g., medications, supplies in rooms/departments, etc.)?	663
Redundancy reduction	16_ Orders have to be clarified:There are times when it seems that work is redundant or unnecessary in the following situations:	552
	17_Redundant information is gathered:There are times when it seems that work is redundant or unnecessary in the following situations:	483
	18_Unnecessary regulatory paperwork is required:There are times when it seems that work is redundant or unnecessary in the following situations:	452
	19_ Accounting for missing medications:There are times when it seems that work is redundant or unnecessary in the following situations:	595
Tasks without interruption	8_How frequently are you interrupted by patients while you are working on something else?	433
	9_How frequently are you interrupted by physicians while you are working on something else?	577
	10_How frequently are you interrupted by other staff while you are working on something else?	457

Table 1: Survey Questions' Scores

Interview responses are transcribed into an excel sheet with 237 rows and 9 columns. Four data points were lost during the transcription process. The qualitative analysis is done in two parts:

Part 1: Taking contextual sentiment into account, root problems are assigned "hash tags" and further categorized into their **"Response Categories"** as illustrated in *Figure 3. "Paperwork"* is an interesting category that implies that in spite of having an EMR, there is large amount of paperwork that exists and

attributes to redundant workflow. This can also be interpreted as functional inefficiency of the EMR. The six IT related problem areas with their respective 'specific feedback indicators' or 'hash tags' are illustrated in *Figure 3*.

S. No.	Response Categories for answers to Interview Q1 and Q2	Frequency	Specific Feedback Inclusions
1	EMR related:	13	Need for training Software hangs Functional improvement in EMR systems Although EMR is present but there is a lot of paperwork to complement the existing workflow Its automated but not paperless Problems fetching medical records
2	Paperwork	18	To complement existing EMR system Regulatory Hard copies/ signature
3	Computer	32	Technical glitches Hardware Software Crashes Forget password Employees not trained in computers
4	Phone call	48	On hold Too many Ringing phone Not being answered
5	Connectivity	12	Slow computer Slow internet Wi-Fi problems Slow EMR
6	Fax	5	Fax not working Fax send and receive problems Too many faxes
7	Non-technology	85	Transportation related Doctor related – doctor is busy in ER Patient related – bring in multiple problems, are late for appointment Staffing shortages, workload Distance Substitute drugs – prescribed drugs not available
8	Insurance Related	7	Prior Authorizations Medicines not covered Dealing with denials Routine coordination with insurance
9	Missing Values	17	Missing values Missing records I don't know I don't deal Not answered - e.g. responding with a different story that has no relation to the question

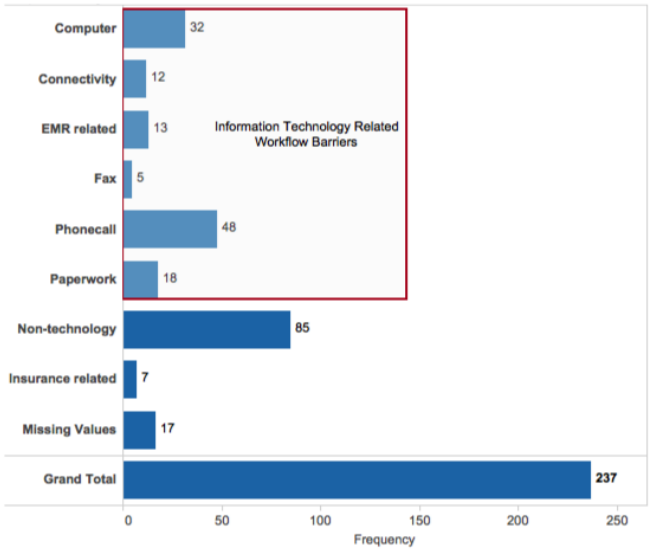


Figure 2: Qualitative Analysis from Interview Responses

The qualitative and the quantitative data analysis individually revealed information that led us to dig deeper into the problem and test the hypothesis that if the means of six Information Technology related qualitative barriers have any significant difference within quantitative redundancy and idle time variables. The dependent variables are questions Q16, 17,18 and 22 *(marked in **green** in Table 1)* and **"Idle_Time_Generation"** covered in Q15 *(marked in **red** in Table 1)*. The independent categorical variable is a derived variable called, "Routine_Technological_Problems" created after a careful qualitative analysis of responses from interview question 1: 'What 3 to 5 factors cause delays in your daily work routine?' and question 2: 'Out of those factors listed above, what is the main issue that delays your routine?' The identified, six "Information Technology Related Workflow Barriers" constitute for more than 50% of the total and clearly indicate the magnitude of problems associated with Information Technology. Non-technology related factors include: no-shows, late arrivals, and other issues related to doctor, patient, or insurance that routinely affects clinical workflow.

With the help of unique response ID's the quantitative and qualitative data is combined to form a new dataset of 237 unique observations with corresponding, survey (quantitative) scores for Q15, Q16, Q17, Q18, Q22 and interview (qualitative) categories for the new variable "Routine_Technological_Problems"

Part 2: Second part of qualitative analysis involves the use of SAS Text Miner to identify the concept linkages in the interview responses. In order to comply with the text mining tool requirements the excel file is split according to response per question using Microsoft Visual Basic. In other words, 237 rows (respondents) * 9 columns (question responses) are separated and resultant 2133 individual files are analyzed using SAS Text Miner.

TEXT ANALYSIS: FOR QUALITATIVE DATA INSIGHTS

Topic Mining is proving to be a popular way of summarizing the common themes in qualitative surveys. Carefully generated results are also helping in building predictive models across service industries.[3] Therefore, SAS Text Miner is used to analyze the transcribed 2133 qualitative data points and graphically represent the hidden common themes. Concept linkages illustrates various reoccurring themes that run

throughout the qualitative data, which otherwise is extremely difficult to represent. Subsequently, text mining results helps in providing structure and validating qualitative analysis results. Clustering group similar topics and words in close proximity next to each other. Numerous concepts made available as branches are expanded for the IT related barriers derived from interviews and qualitative comparisons are derived.

Figure 3, shows the text-mining model in SAS Text Miner while *Display 1*, is an exhibit of the output of Text Import Node or Input to Text Parsing Node.

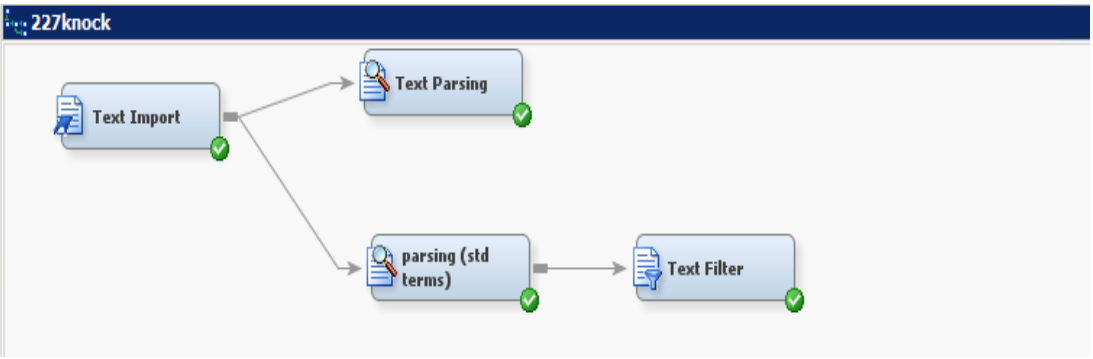
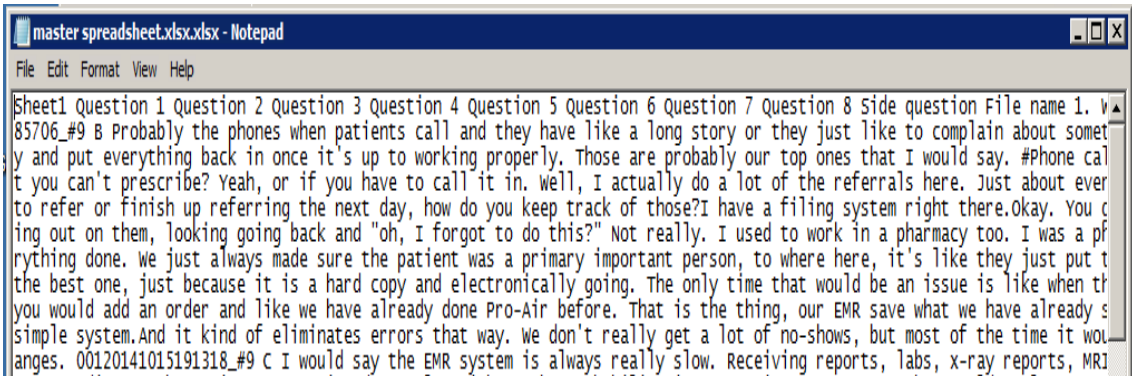


Figure 3: Text Mining Model



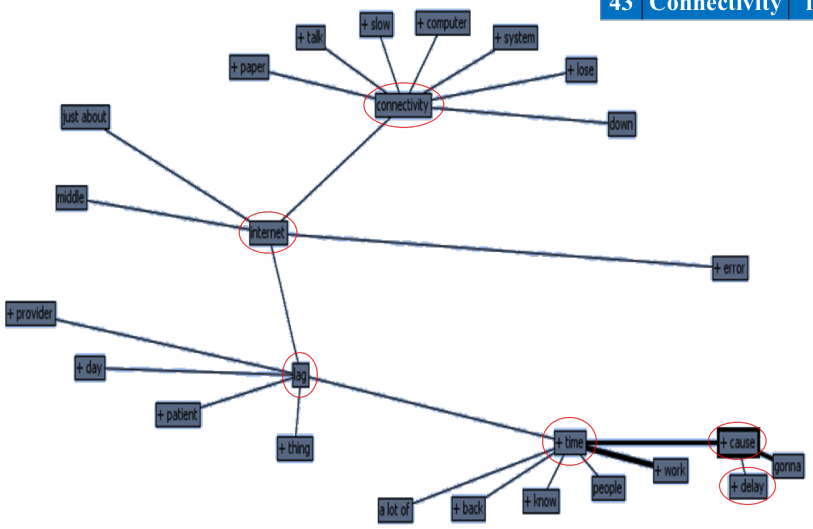
Display 1: Input to Text Parsing Node

SAS Text Miner generated many concept link maps with themes revolving around Pharmacy, Lack of Transportation/Rides, No-shows, Connectivity, Paperwork, Computers, etc., *Output 1* and *Output 2* of the analysis demonstrate the IT related themes of “Connectivity” and “Paperwork”

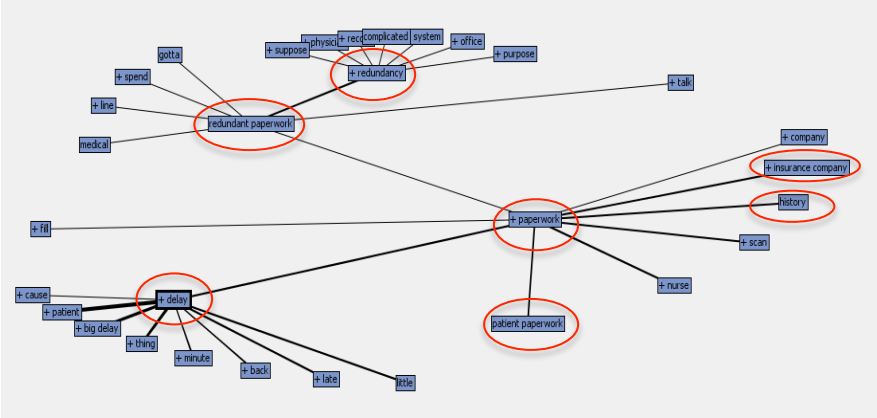
The IT related meaningful concept linking words are:

- Connectivity- internet- lag- time-cause- delay
- Redundant- redundant paperwork- paperwork- patient- big- big deal- horrible- long-time
- Interruption- phone- ring- a lot of- issues
- Interruption- concern- complaint- problem- pharmacy- fax
- Routine- daily routine- fax- fax machine- major- a lot of- issue

43	Connectivity	internet	lag	time	cause	delay



Output 1: SAS Text Mining Concept Linking Map: Connectivity



Output 2: SAS Text Mining Concept Linking Map: Paperwork

You can now identify various research questions with the help of SAS Text Miner results and build more structured causal or predictive models. However, this paper utilized the above results only for descriptive and validation purposes.

DATA ANALYSIS: A MIXED METHOD APPROACH

The final cleaned dataset has approximately 7% to 20% missing values in categorical and numerical variables respectively. The reason for missing values is assumed to be data loss during transcription and data transfer and all missing values are “Missing Completely At Random (MCAR).”

Missing values are imputed for both categorical and interval variables using the Impute node in SAS Enterprise Miner with the Distribution method and the imputed SAS dataset is exported for the final analysis in SAS Enterprise Guide. A new variable **“Redundancy_Consolidated”** is created which is the average of scores for Q_16, 17, 18 and 22. This variable is a composite of the four redundancy related interval variable and will serve as the dependent variable for analyzing the relationship between the qualitative and quantitative variables of interest. This dataset is sorted to include only the six Information

Technology related treatment groups (Computer, Connectivity, EMR, Fax, Phonecall and Paperwork) for the variable “Routine_Technological_Problems”.

Display 2 exhibits the final dataset with the imputed values and the newly computed variable “Redunancy_Consolidated”, sorted for the six categorical treatment groups with 140 unique observations.

	Response_ID	Routine_Technological_Problems	Idle_Time_Generation	Q_16_Red	Q_17_Red	Q_18_Red	Q_22_Red	Redundancy_Consolidated
1	C11	Phonecalls	5	5	5	4	4	4.5
2	C12	Phonecalls	5	3	5	5	3	4
3	C13	Phonecalls	4	4	4	4	4	4
4	C14	EMR related	3	3	3	3	4	3.25
5	C18	Phonecalls	5	4	3	5	3	3.75
6	C19	Phonecalls	5	3	5	3	3	3.5
7	C110	Paperwork	5	5	3	3	4	3.75
8	C21	Connectivity	3	4	3	3	4	3.5
9	C22	Connectivity	4	5	4	5	4	4.5
10	C24	Paperwork	5	4	4	4	4	4
11	C25	Phonecalls	4	4	4	5	4	4.25
12	C26	Phonecalls	4	4	4	5	4	4.25
13	C31	EMR related	5	3	5	5	4	4.25
14	C34	Paperwork	4	3	5	5	3	4
15	C35	Paperwork	5	3	3	5	4	3.75

Display 2: Imputed Final Dataset

A linear regression model is set up to test the hypothesized relationship between quantitative and the qualitative variables.

ANOVA works well with balanced data, i.e. when each treatment levels are of same size or at least 15 in number. If this condition is not met, GLM is considered to be a robust substitute.[4]

However, our final dataset is not balanced for one-way ANOVA. *Output 3* shows the one-way frequency from SAS EG. Therefore, SAS EG is used to test both ANOVA and GLM models to account for the unbalanced sample size for the six treatment groups.

One-Way Frequencies

Results

The FREQ Procedure

Routine_Technological_Problems	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Computer	35	25.00	35	25.00
Connectivity	13	9.29	48	34.29
EMR related	13	9.29	61	43.57
Fax	6	4.29	67	47.86
Paperwork	21	15.00	88	62.86
Phonecalls	52	37.14	140	100.00

Output 3: One-way Frequencies for Categorical Variable

PROC ANOVA AND PROC GLM RESULTS FOR REDUNDANCY_CONSOLIDATED

Results for one-way ANOVA are not significant at 5% significance level with a p-value of 0.06 (*Output 4*). Means Box plot is requested in the output for a visual snapshot, shown in *Output 5*. On the other hand GLM Model gives a significant p-value, but the model fails to explain the variability with an R-square close to zero and a poor model fit.

One-Way Analysis of Variance

Results

The ANOVA Procedure

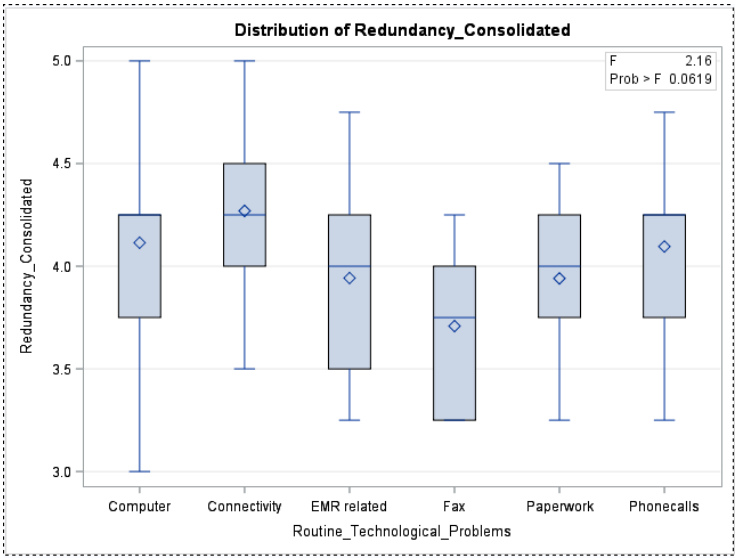
Dependent Variable: Redundancy_Consolidated

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	1.96143544	0.39228709	2.16	0.0619
Error	134	24.30418956	0.18137455		
Corrected Total	139	26.26562500			

R-Square	Coeff Var	Root MSE	Redundancy_Consolidated Mean
0.074677	10.48322	0.425881	4.062500

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Routine_Technologica	5	1.96143544	0.39228709	2.16	0.0619

Output 4: Proc ANOVA Results for Redundancy



Output 5: Means Plot – Proc ANOVA for Redundancy

The GLM Procedure

Dependent Variable: Redundancy_Consolidated

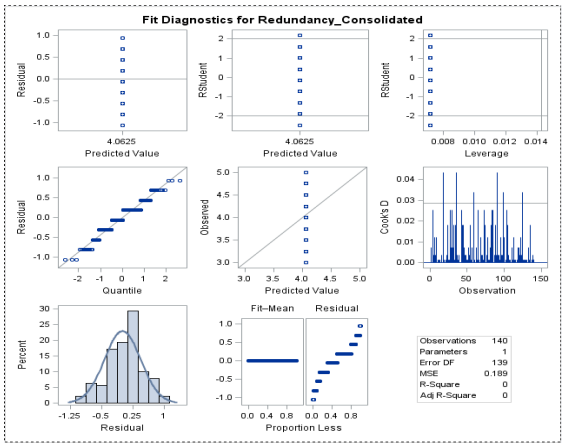
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	2310.546875	2310.546875	12227.6	<.0001
Error	139	26.265625	0.188961		
Uncorrected Total	140	2336.812500			

R-Square	Coeff Var	Root MSE	Redundancy_Consolidated Mean
0.000000	10.70023	0.434697	4.062500

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Intercept	1	2310.546875	2310.546875	12227.6	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Intercept	1	2310.546875	2310.546875	12227.6	<.0001

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	4.062500000	0.03673859	110.58	<.0001



Output 6: Proc GLM Results for Redundancy

PROC ANOVA AND PROC GLM RESULTS FOR IDLE_TIME_GENERATION

Results for one-way ANOVA are not significant at 5% significance level with a p-value of 0.87 (*Output 4*). Means Box plot is requested in the output for a visual snapshot, shown in *Output 8*. On the other hand, the GLM Model gives a significant p value, but the model fails to explain the variability with an R-square close to zero and a poor model fit.

One-Way Analysis of Variance

Results

The ANOVA Procedure

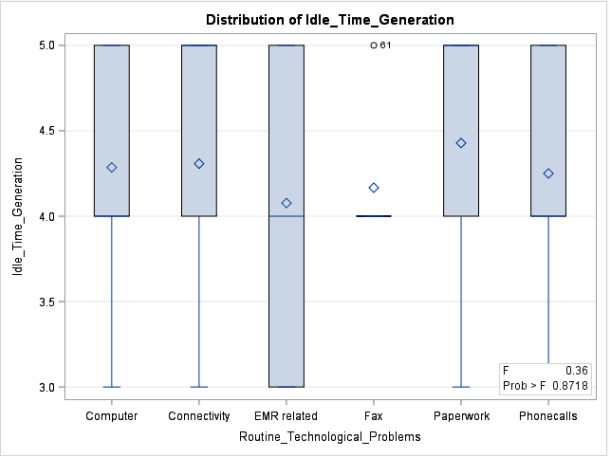
Dependent Variable: Idle_Time_Generation

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	1.12435897	0.22487179	0.36	0.8718
Error	134	82.56135531	0.61612952		
Corrected Total	139	83.68571429			

R-Square	Coeff Var	Root MSE	Idle_Time_Generation Mean
0.013435	18.37650	0.784939	4.271429

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Routine_Technologica	5	1.12435897	0.22487179	0.36	0.8718

Output 7: Proc ANOVA Results for Idle Time



Output 8: Means Plot – Proc ANOVA for Idle Time

Linear Models

The GLM Procedure

Dependent Variable: Idle_Time_Generation

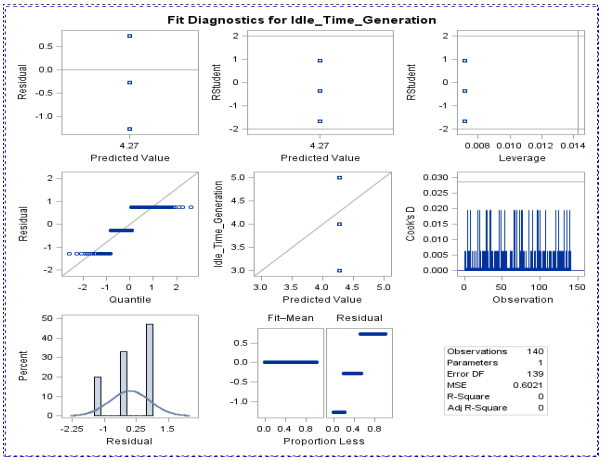
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	2554.314286	2554.314286	4242.66	<.0001
Error	139	83.685714	0.602055		
Uncorrected Total	140	2638.000000			

R-Square	Coeff Var	Root MSE	Idle_Time_Generation Mean
0.000000	18.16541	0.775922	4.271429

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Intercept	1	2554.314286	2554.314286	4242.66	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Intercept	1	2554.314286	2554.314286	4242.66	<.0001

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	4.271428571	0.06557741	65.14	<.0001



Output 9: Proc GLM Results for Idle Time

Discussion

The results implies that there is not a significant linear relationship between the IT Related treatment groups and the variables measuring perception of Redundancy and Idle Time within the context of workflow in the primary care clinic in rural Oklahoma.

There can be various reasons for the insignificant and poorly fit models like diminutive relationship between dependent and independent variables, specification errors, or measurement errors.[5]

Although the linear regression results are not significant the Text Mining results show how these IT related barriers have strong associations to workflow barrier related words and perceptions.

IT related issues seem to be interwoven, and there might be various mediating effects that have an impact on responder's perception of redundancy and idle time related questions. This is a valid question and needs more structured study design and evaluation to glean more insight.

Conclusion

Technology promises to ease the workflow in any organization but there are various underlying elements that make its implementation and usage a cumbersome activity, usually followed by time periods of resistance and reduced efficiency. Rural Primary care clinics are already ailing with scarce resources, missed appointments, financial instability, etc., upon which these routine information technology related issues are of a compounding nature.

The study was unable to identify significant relationships among IT related factors and workflow inefficiencies. This outcome is somewhat consistent with the aforementioned research that failed to find a significant statistical relationship between broadband availability and EMR adoption in rural Oklahoma.[2]

Further research on technological impacts in rural clinics is warranted with a structured and systematic research design. The quest to explain technology related barriers in rural health is still not satisfied but its progression, shall most likely result in better revenues, higher patient and employee satisfaction, and optimum utilization of interoperable platforms in primary care delivery.

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