



Final Review: Coastal Connect Health Information Exchange Key Findings on Value for Providers to Participate

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Executive Summary

PURPOSE OF THIS REPORT: In 2009, Coastal Connect Health Information Exchange (CCHIE) was established through the collaborative efforts of member hospitals of the Coastal Carolinas Health Alliance (CCHA) to enable electronic exchange to improve quality, safety, and efficiency of healthcare for patients in their communities. CCHIE is a nonprofit regional health information organization dedicated to enabling the secure and reliable exchange of health information in Eastern North Carolina. Supported by a grant from The Duke Endowment, CCHIE engaged in a three-year project to connect Community Care of North Carolina (CCNC) providers, safety-net organizations, and identified specialists to a HIE network. By electronically sharing patient data, CCHIE intended to increase the efficiency of patient care and improve care coordination.

BACKGROUND: Health information exchange (HIE) refers to the real time transfer of electronic health information among affiliated and nonaffiliated healthcare providers. It makes health information interoperable, so that efficiency is boosted, health costs are reduced, and care quality is improved.¹ As the federal government is striving to transform the U.S. health system into patient-centered and value-based, many new programs such as Accountable Care Organizations and bundled payments emphasize coordinated care orchestrated by various healthcare stakeholders. Interoperable information sharing enabled by HIE is critical for care coordination and the ultimate transformation of our health care system. HIE adoption is encouraged by the “meaningful use” program of the Health Information Technology for Economic and Clinical Health (HITECH) Act of 2009. As of 2013, 62% of hospitals and 39% of office-based physicians engaged in some type of HIE with external organizations.² Despite the great potential benefits and increasing adoption of HIE, there is no consensus regarding the effects of HIE. A recent review finds that the extant literature on HIE has not provided adequate rigorous evidence for the benefits of HIE.¹

OBJECTIVE: To conduct a three year outcome assessment for HIE implementation and adoption in participating physician practices from 2012 to 2014.

SUMMARY OF FINDINGS: The usage level of CCHIE, measured by the number of user logins, grew rapidly during the three years. The monthly usage in 2012 and 2013 was all under 500, and the monthly usage in 2014 increased from 1000 to over 2000. Compared with the usage in June 2012, the usage in December 2014 increased by 4.29 times. Average monthly growth rate is 14.14%. In 2014, total usage volume is more than 6 times greater than the total usage volume in 2013.

Data quality of CCHIE was measured from four perspectives: accuracy, reliability, completeness, and timeliness. All user ratings were no less than 5 on a 1 to 7 disagree/agree scale with 5 being slightly agree, suggesting that on average all of the users agreed that the CCHIE data are of high quality. For each dimension, ratings were lowest during the initial year of surveying (2012) and

increased yearly. This suggests that as the users gained more knowledge about CCHIE, they perceived higher data quality.

Efficiency of CCHIE was measured by using five factors: (1) overall reduced time, (2) reduced administrative time, (3) increased data flow efficiency, (4) reduced test redundancy, and (5) reduced costs. From 2012 to 2014 each of these efficiency factors increased annually. In 2012 each factor rated between 4 (neutral) and 5 (slightly agree). By 2013 the ratings for overall reduced time, reduced administrative time, and increased data flow efficiency had surpassed 5. The rating for reduced test redundancy surpassed 5 the following year (2014) when all of the factors continued to increase. Only the rating for reduced costs remained under 5 during those years. 2014's high ratings suggest that time reduction, data flow efficiency, test redundancy reduction, and cost reduction were achieved in the practices after a period of adjustment and staff utilization of the HIE to better understand its functionality.

Clinical value of CCHIE was measured by user perceptions. CCHIE's most important value is data sharing through inquiries and results delivery. Initially, the perceived value was below 5 in 2012; however, this grew remarkably stronger by 2014 despite a slight decline between 2013 and 2014. This result suggests that through usage and better knowledge of the tools, users' understanding of CCHIE's value deepened and their value perceptions became measurably stronger. In addition, we found that users progressively realized the value of CCHIE depends on a large number of data contributors since they need to access data from providers outside of their organization.

User trust in the CCHIE organization was measured from two aspects: trustworthiness and competence. Users' perceptions of competence and trustworthiness of CCHIE continuously climbed between 2012 and 2014. This increased rating could have resulted from users' positive experience with the CCHIE system and personal interaction with CCHIE staff.

User satisfaction with CCHIE evaluated four aspects: (1) CCHIE's capability to provide data access to other providers, (2) CCHIE's capability to provide secure data sharing, (3) CCHIE's adaptability to fit with users' specific needs, and (4) users' overall satisfaction with CCHIE. In terms of enabling data access and providing secure data sharing, the ratings exhibit an upward trend, although the rating differences between 2013 and 2014 are small. For adaptability, the ratings remained relatively stable over the three years with only slight variation. When considering CCHIE as a whole, users' satisfaction level began relatively low in 2012, but by 2013 the satisfaction rating had jumped from 4.75 to 5.57 before increasing again in 2014 to 5.69. Overall, despite low numbers in 2012 all of the ratings in the four aspects of user satisfaction exceeded 5.5 in 2014, suggesting that the users are generally satisfied with the CCHIE functionalities.

Relationships among the key factors were analyzed by using an advanced statistical technique called Partial Least Square (PLS). We identified seven latent variables and used PLS to analyze three models, which represent the relationships among those seven variables. It was found that

(1) observed efficiency is significantly influenced by three factors: data quality, data accessibility, and compatibility; (2) perceived value is significantly influenced by three factors: data accessibility, compatibility, and observed efficiency; and (3) satisfaction is significantly influenced by two factors: perceived value and compatibility.

Overall, the results of this three-year study provide strong support to the positive outcomes of the CCHIE implementation model within the participating practices. The high ratings of the key variables confirm users' positive perceptions of and attitudes toward CCHIE as well as their observation of the actual efficiency improvements and value.

Methodology

The purpose of the academic review was to evaluate CCHIE implementation outcomes based on participating physician practices' perceptions and attitudes. The evaluation had been continuously carried out throughout a three-year period from 2012 to 2014. During each of those years, a survey collected data from physician practices and initiated additional phone interviews with selected respondents. Additionally, we tracked user logins longitudinally over time and analyzed the trend.

Development of the survey questions focused on the key concerns of CCHIE's implementation team, so that the results could be used to monitor the progress of the project and help improve the implementation outcome. Specifically, our questions aimed to evaluate CCHIE implementation from several perspectives, including clinical value, efficiency, data quality, trust, and satisfaction. Initial survey questions were developed based on a literature review of prior research on health information technologies in general and HIE in particular. These questions were then reviewed by key stakeholders of CCHIE. Each question utilized a 7-point Likert scale with 1 indicating "Strongly disagree" and 7 indicating "Strongly agree." Respondents were allowed to select "N/A" if they thought the question was not applicable to his or her practice. In 2013 and 2014, these questions were slightly adjusted to reflect changes in the implementation process.

Each year the survey was distributed to all of the physician practices that had installed the CCHIE application. The survey was developed on qualtrics.com, so it could be completed electronically. All potential respondents received email invitations for the survey followed by two rounds of reminder emails. In order to increase response rate, a small monetary incentive was offered to each participant for completing the survey. Response rates were recorded as such: in 2012, 14 out of 41 respondents completed the survey, a rate of 34%; 2013, 63 out of 182 respondents completed the survey, a rate of 39%; and in 2014, 126 out of 626 respondents completed the survey, a rate of 20%.

Evaluation Findings

Usage

Volume of usage has long been treated as an important indicator of the implementation outcome of information systems.³ The number of user logins represented CCHIE usage volume. To accurately estimate volume of CCHIE usage, the data of monthly user logins was retrieved from the CCHIE data base. We selected 31 practices with data from June 2012 to December 2014 and calculated their total number of user logins. As Figure 1 shows, monthly usage in 2012 and 2013 remained under 500; however, monthly usage in 2014 increased from 1,000 to over 2,000. Compared with June 2012 numbers, usage in December 2014 had increased 4.29

times. Average monthly growth rate was 14.14%. By 2014 total usage volume reached 20,140, which is more than six times higher than the total usage volume in 2013 (3225).

Further statistical analysis revealed that the growth pattern of CCHIE usage fits a quadratic U-shaped curve (Figure 2). The regression function is: $Use = 463.28 - 68.58*t + 4.32*t^2$, where t represents time. This function explains 88% variance in the data, indicating an excellent fit. The U-shaped curve suggests that usage slightly decreased in the early stages of CCHIE implementation before boosting in the later stage. This growth pattern is expected. The usage level was relatively high at the very beginning because users needed to log in frequently to test the system. Once the system was installed, the usage level dropped a bit because there was a shakedown phase during which users were still trying to figure out how to integrate the system into their job routines. After users became familiar with the system and realized its advantages, they started to use the system more heavily, and the usage level climbed up.

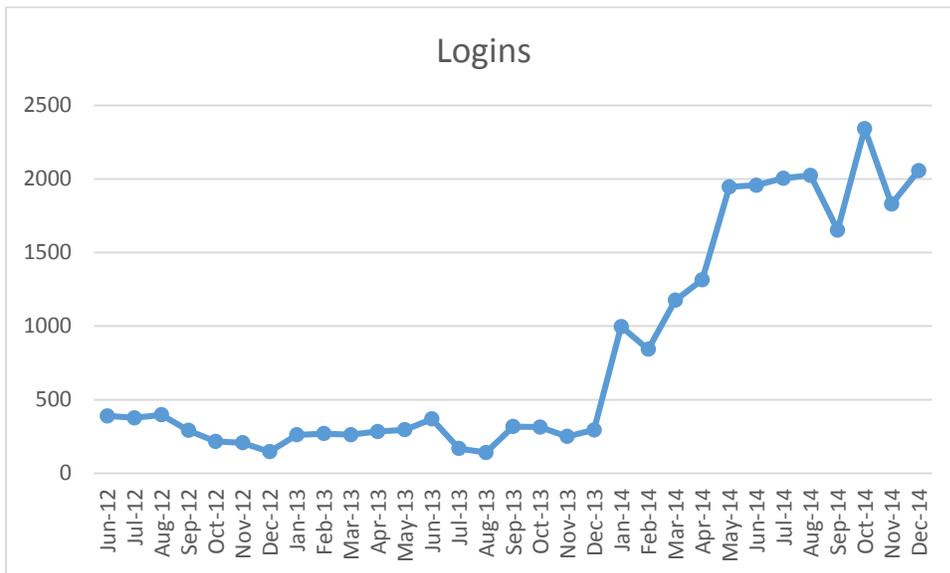


Figure 1. Total CCHIE logins from 2012 to 2014

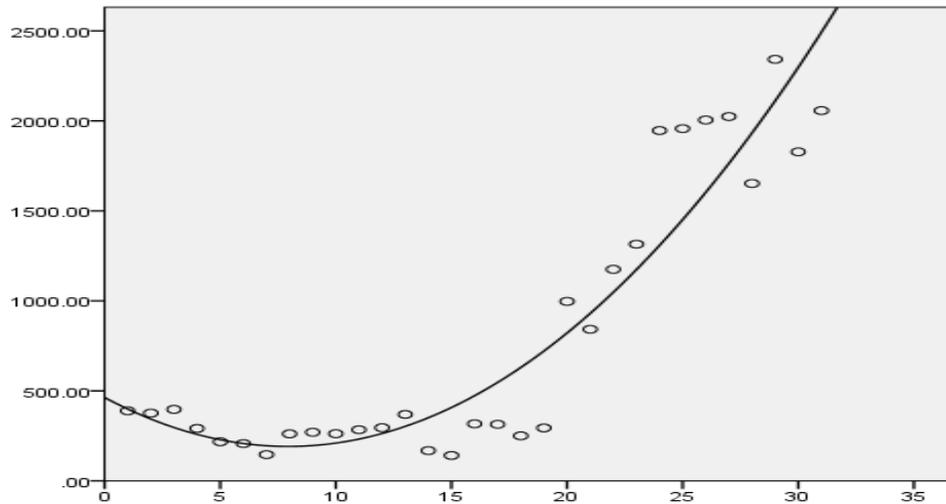


Figure 2. The growth trend of CCHIE usage

Data Quality

Data quality is often considered a critical dimension of information system success.^{4, 5} Given that the most important objective of HIE is to improve interoperable care by sharing patient data among providers, data quality is an indispensable component when evaluating CCHIE implementation outcomes. Data quality of CCHIE was measured from four perspectives: accuracy, reliability, completeness, and timeliness. Accuracy refers to the extent to which the CCHIE data is correct and free of errors. Reliability means the data is consistent across multiple queries. Completeness is defined as the extent to which users are able to get all of the data that they need through CCHIE. Timeliness pertains to how quickly the requested data becomes available to the users.

In each of the three-year study period, we measured CCHIE users’ perceptions of data quality in the four dimensions. Figure 3 illustrates the average ratings of those data quality dimensions across three years. All of the ratings are no less than 5, suggesting that on average all of the users agreed that the CCHIE data are of high quality. For each dimension, the lowest ratings were recorded in 2012 and then increased yearly. This suggests that as the users gained more knowledge about CCHIE, they perceived higher data quality. Accuracy and reliability consistently received higher ratings than completeness and timeliness across all three years, indicating how there is more room for improvement for completeness and timeliness than accuracy and reliability.

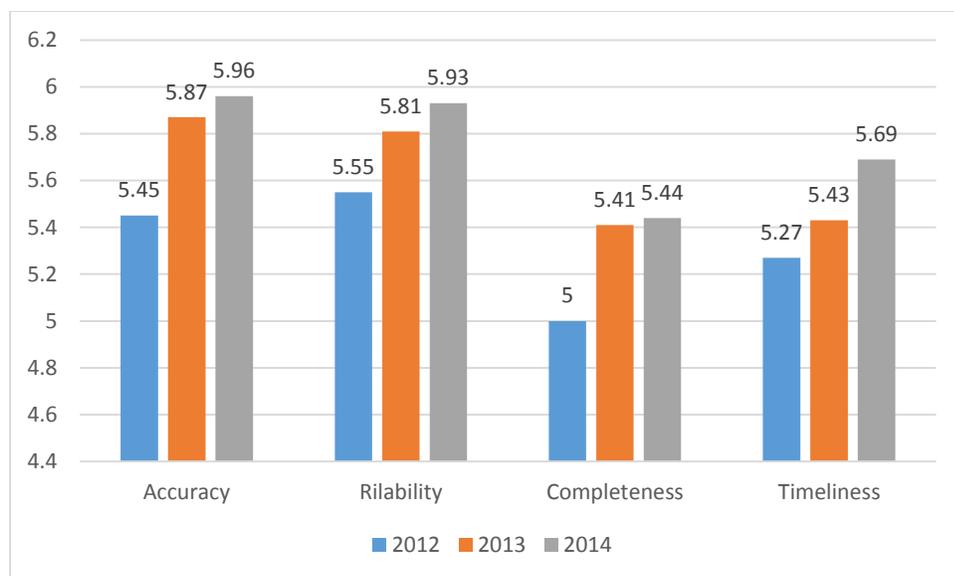


Figure 3. Data quality measures during the three years

Observed Efficiency

Efficiency is one of the most frequently reported benefits resulting from HIE.¹ To evaluate how CCHIE has improved efficiency in the physician practices, we measured five factors: (1) overall reduced time, (2) reduced administrative time, (3) increased data flow efficiency, (4) reduced test redundancy, and (5) reduced costs. Each year, we asked whether the CCHIE users’ have observed the five types of efficiency associated with CCHIE use. Figure 4 shows the average ratings of the five efficiency dimensions across the three years.

Each efficiency factor’s rating increased annually from 2012 to 2014. In 2012, ratings were between 4 (neutral) and 5 (slightly agree), suggesting that users were not able to confirm that they observed concrete efficiencies in the early implementation stage. By 2013, ratings for overall reduced time, reduced administrative time, and increased data flow efficiency surpassed 5; meanwhile ratings for reduced test redundancy and reduced costs remained under 5. In 2014, all of the ratings continued to heighten and, except for reduced costs, surpassed 5. These results indicate that the users were able to observe more efficiencies as their CCHIE usage level grew. It seems difficult for users to observe cost reduction associated with CCHIE usage, possibly because the estimation of cost savings requires a complicated calculation process that cannot be done easily based on observations. The high ratings in 2014 indicate that continued use of CCHIE achieved time reduction, data flow efficiency, test redundancy reduction, and cost reduction.

Evaluation of CCHIE

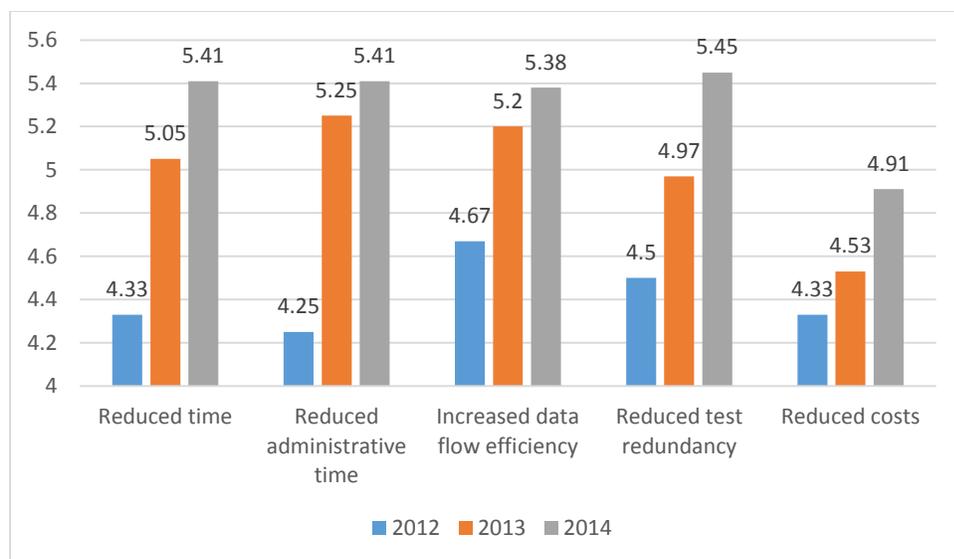


Figure 4. Observed efficiency measures during the three years

Value Perceptions of CCHIE

Clinical value of CCHIE was measured by user perceptions. Different questions were asked each year based on the project progress. (Table 1 shows the different questions asked in each year and their accompanying ratings.) Although the questions varied by year, the substantive content of these questions were all concerned with whether the users believed the CCHIE functions were valuable to their practices. To make the results comparable across years, we calculated a single score by averaging the question ratings in each year so that one year has a single average rating to represent perceived value of CCHIE. As Table 5 shows, the perceived value is below 5 in 2012, suggesting that although users believed in the value of CCHIE their beliefs were not strong. This changed over the next two years, during which time perceived value grew stronger despite a slight decline between 2013 and 2014. This suggests that as users gained more knowledge about CCHIE through usage, their understanding of the value of CCHIE was deepened and their value perceptions became stronger.

In addition, we asked whether the users believe that the value of CCHIE will increase as more providers join the CCHIE network. As Figure 5 shows, the rating of this question increased every year, from 5.57 in 2012 to 6.23 in 2014. This ascending pattern suggests that as users face the need to access data from providers outside their organization when using CCHIE, they progressively realize that the value of CCHIE depends on a large number of providers sharing patient data.

Table 1. Survey questions for CCHIE value in different years

Year	Survey Questions	Mean	Std
2012	CCHIE provides value to my practice through:		
	... referral tracking	5.09	2.26
	... result delivery	4.85	2.27
2013	iNexx results delivery through CCHIE provides great value to my practice	5.63	1.19
	Patient Summary Inquiry of CCHIE provides great value to my practice	5.75	1.14
	Overall, CCHIE provides great value to my practice	5.72	1.17
2014	The Community Record tool of CCHIE provides great value to my practice	5.72	1.25
	Accessing radiology transcription from Delaney Radiologists on the HIE has been of value	5.63	1.32
	Accessing Community of Care Documents (CCDs) from Southeastern Health Clinics on the HIE has been of value	5.37	1.30
	Accessing pathology and lab results from Solstas on the HIE will be of value (following go live 11/7/2014)	5.82	1.19
	Results delivered through CCHIE to a work list or my clinical inbox inside the Community Health Record provide great value to my practice	5.41	1.47
	Results delivered into our EMR, directly into the patient chart, through CCHIE provide great value to my practice	5.36	1.61

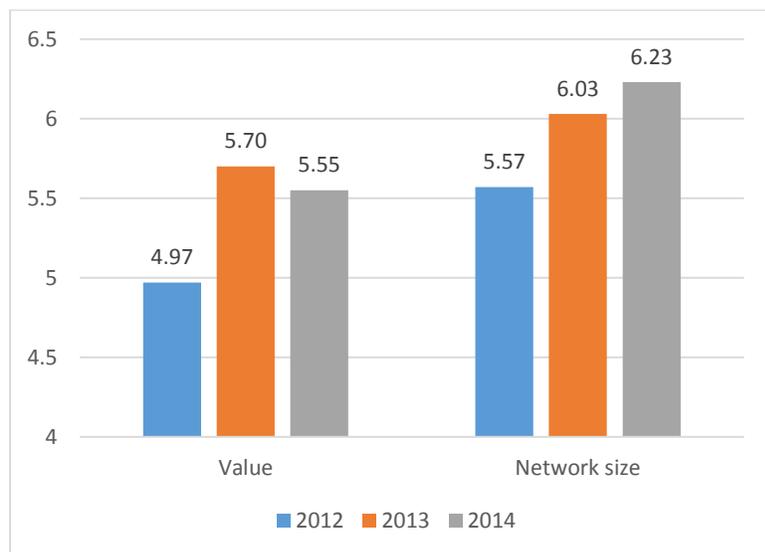


Figure 5. Perceived value of CCHIE across years

Trust in CCHIE

Users’ trust perception of the CCHIE organization will inevitably affect their perceptions of the CCHIE system.⁶ Therefore, we measured two attributes of CCHIE: trustworthiness and competence. As Figure 6 shows, the users only slightly agreed that CCHIE was competent and trustworthy in 2012. As time passed, their perceptions of competence and trustworthiness of CCHIE continuously increased. The 2014 ratings of both measures were the highest of the three

years. This increased ratings could be explained from two perspectives. First, as the users gained more experience with the CCHIE system and observed its benefits, they were likely to give credit to the CCHIE organization. Second, when the CCHIE system was implemented and used in each practice, CCHIE staff closely interacted with the users. The personal interaction increased the users' familiarity with CCHIE, helping them appreciate the staff's competence and develop a sense of trust in CCHIE.

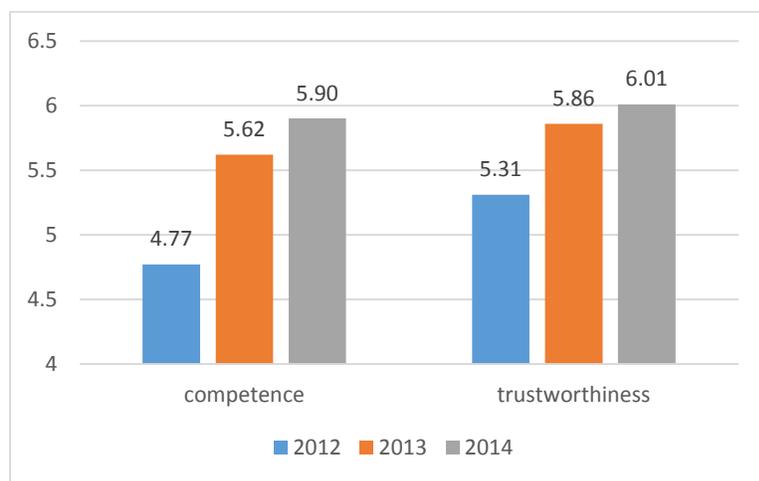


Figure 6. User perceptions of Coastal Connect

Satisfaction

Given that CCHIE is an information system that is operated by users and fulfills user needs, user satisfaction is an important indicator of implementation success.⁴ We evaluated user satisfaction in four aspects: (1) CCHIE's capability to provide data access to other providers, (2) CCHIE's capability to provide secure data sharing, (3) CCHIE's adaptability to fit with users' specific needs, and (4) users' overall satisfaction with CCHIE. Figure 7 shows the change patterns of these measures over the three year period. In terms of enabling data access and providing secure data sharing, the ratings exhibit an upward trend, although the rating differences between 2013 and 2014 are small. For adaptability, the ratings remained relatively stable over the three years and only showed slight variation. The lack of an upward pattern for adaptability possibly stems from the fact that the CCHIE system provides a standard set of functionalities to all the practices. All customization was completed at the time the system was installed, and the core functionalities of CCHIE cannot be adapted to meet each practice's unique needs.

When considering CCHIE as a whole, the users' satisfaction level began relatively low in 2012. However, the satisfaction rating jumped up from 4.75 to 5.57 in 2013 and had another increase in 2014 to reach 5.69. Many factors could have contributed to the low satisfaction in 2012. For

example, it is typical for users to experience frustration and anxiety when first exposed to an unfamiliar system that requires extra time and efforts to learn how to operate. When their knowledge and skills of using the system increased, they realized the usefulness of CCHIE, and their attitudes began to change. Overall, despite low ratings in 2012, all of the ratings in the four aspects of user satisfaction exceeded 5.5 by 2014, suggesting that the users are generally satisfied with the CCHIE capabilities.

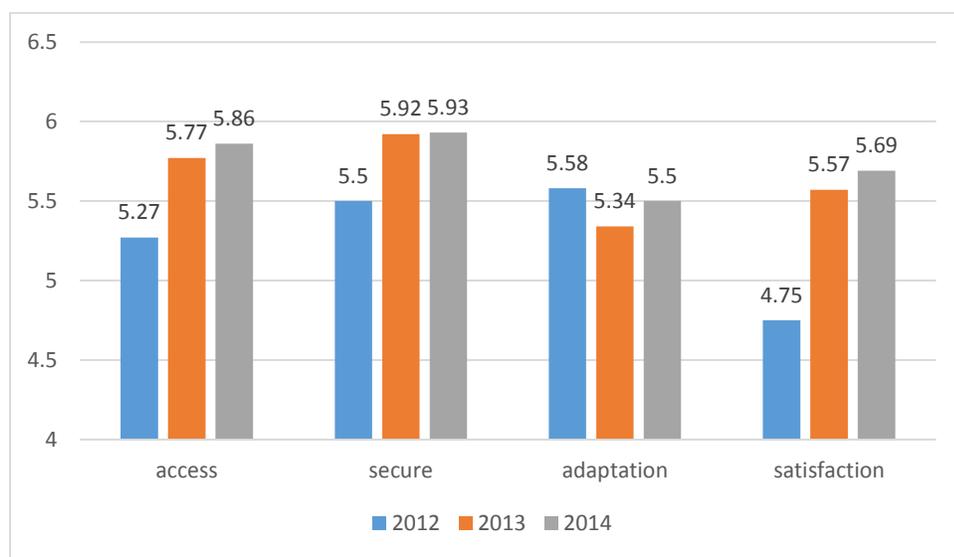


Figure 7. User satisfaction with CCHIE

Relationships among Key Factors

To understand the relationships among the key factors related to the CCHIE implementation, we statistically analyzed the survey data collected in 2014 by using a Structural Equation Modelling approach called Partial Least Square (PLS). The PLS technique can estimate both the structural relationships among latent variables and the measurement errors of each latent variable, which enables it to produce more accurate results than regression techniques.^{7, 8} In this study, we identified seven latent variables and used PLS to analyze three models, which represent the relationships among the seven variables. A latent variable is a higher level factor that consists of one or more indicators (survey questions). The seven factors and their associated indicators are shown in Table 2.

Table 2. Key factors related to CCHIE implementation

Factor	Indicator	Factor Loading
Data quality	Patient data available through CCHIE is:	
	1. ... accurate	0.93*
	2. ... reliable	0.92*

	3. ... complete	0.95*
	4. ... timely	0.94*
Data accessibility	1. Connection to CCHIE enables access to patient data from different providers in different locations/counties	0.89*
	2. Connection to CCHIE maximizes my access to data related to patient care decisions	0.92*
Compatibility	CCHIE is compatible with the current work flow in my practice	1.00
Observed Efficiency	After installing CCHIE at my practice, we observed:	
	1. ... reduced time spent managing patient data	0.92*
	2. ... increased data flow efficiency in my practice	0.92*
	3. ... reduced administrative time spent managing patient data	0.92*
	4. ... avoided redundant tests ordered for patients	0.82*
	5. ... reduced costs for my practice	0.86*
Trust	1. CCHIE is trustworthy	0.95**
	2. CCHIE is competent in enabling providers to share data	0.96**
Perceived value	3. The Community Record tool of CCHIE provides great value to my practice	0.85*
	4. Accessing radiology transcription from Delaney Radiologists on the HIE has been of value	0.77*
	5. Accessing Community of Care Documents (CCDs) from Southeastern Health Clinics on the HIE has been of value	0.74*
	6. Accessing pathology and lab results from Solstas on the HIE will be of value (following go live 11/7/2014)	0.81*
	7. Results delivered through CCHIE to a work list or my clinical inbox inside the Community Health Record provide great value to my practice	0.80*
	8. Results delivered into our EMR, directly into the patient chart, through CCHIE provide great value to my practice	0.75*
Satisfaction	Overall, I'm satisfied with what CCHIE does for my practice	1.00

Note: * indicates significance at the 0.01 level. A high and significant factor loading suggests that the indicator is a valid measure of the factor.

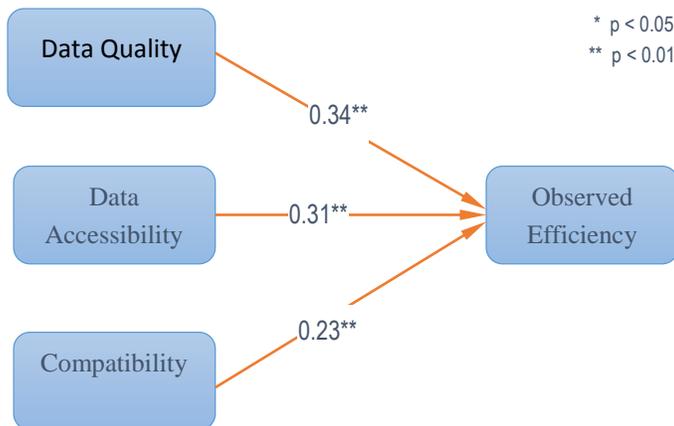


Figure 8. Influencing factors of observed efficiency

The first PLS model depicts how observed efficiency is influenced by data quality, data accessibility, and compatibility. As Figure 8 shows, all of the three factors have significant effects on observed efficiency. That is, when users perceive that the CCHIE data quality is high, CCHIE enables them to access external patient data, and when CCHIE is compatible with their existing work flow, they are likely to observe increased efficiency in their practices.

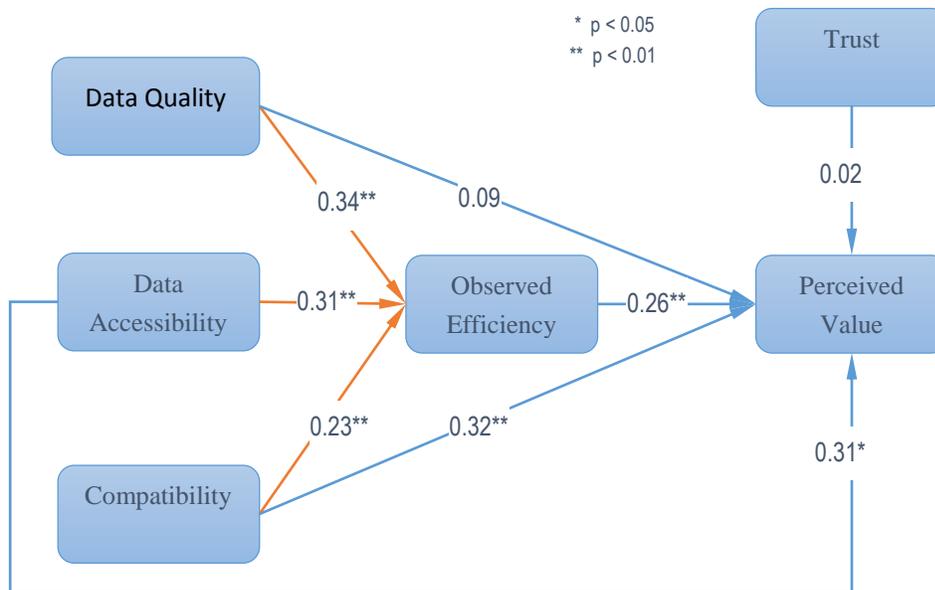


Figure 9. Influencing factors of perceived value

The second model examines how the value perception of CCHIE is shaped. As Figure 9 shows, trust in CCHIE has no significant effect on perceived value. Data quality cannot directly influence perceived value, either. However, it still has an indirect effect on perceived value through observed efficiency, which means that users would not perceive CCHIE to be valuable

unless the high quality data has led to increased efficiency. Observed efficiency, data accessibility, and compatibility significantly enhance perceived value. These results suggest that when users perceive that CCHIE enables them to access external patient data, CCHIE is compatible with their existing work flow, and when they have observed increased efficiency in their practices, they are likely to believe that CCHIE has value for them.

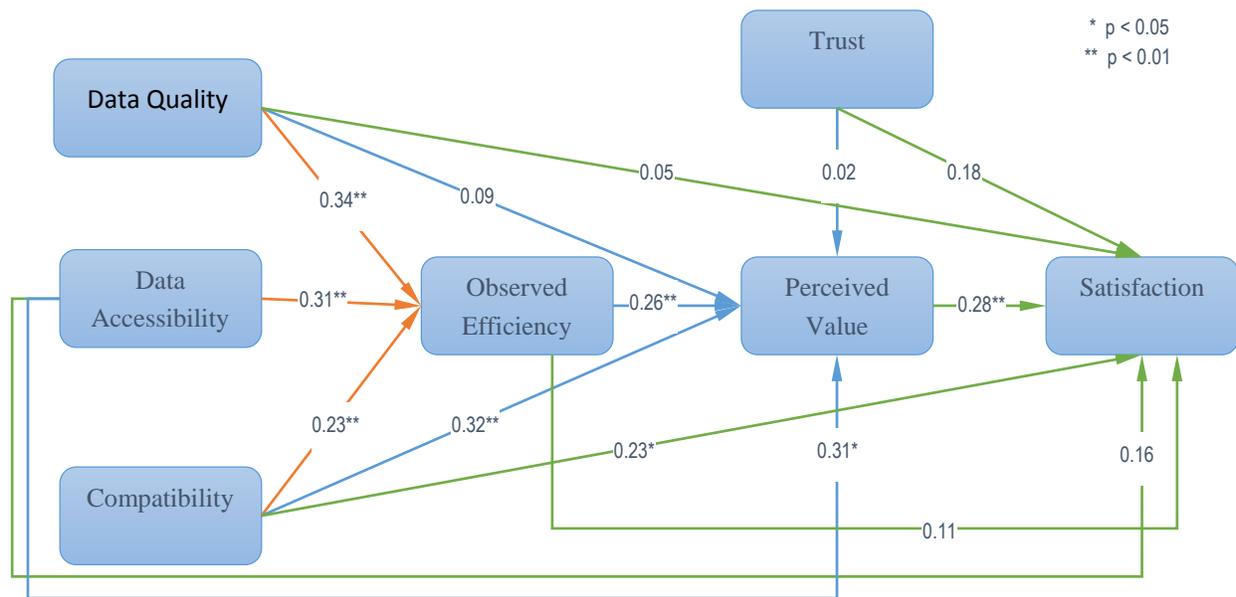


Figure 10. Influencing factors of satisfaction

The third model examines how the six factors in Model 2 influence user satisfaction. As Figure 10 shows, satisfaction is significantly influenced by two factors: perceived value and compatibility. Interestingly, trust, data quality, data accessibility, and observed efficiency have no significant direct effects on satisfaction. Further analysis reveals that the effects of data accessibility and observed efficiency are mediated by perceived value. This means that even if users are enabled to access external patient data and witnessed improved efficiency, they are not necessarily satisfied. The benefits brought by CCHIE have to be internalized by the users and be interpreted as valuable, so that a feeling of satisfaction can be fostered.

Findings from Qualitative Studies

In 2013, 51 users responded to an open-ended question in the survey “How did CCHIE provide benefits to you and your practice?” As shown in Figure 11, the most frequently mentioned benefits include access to external data (35%), saved time in obtaining external data (34%), and ease of obtaining external data (12%).

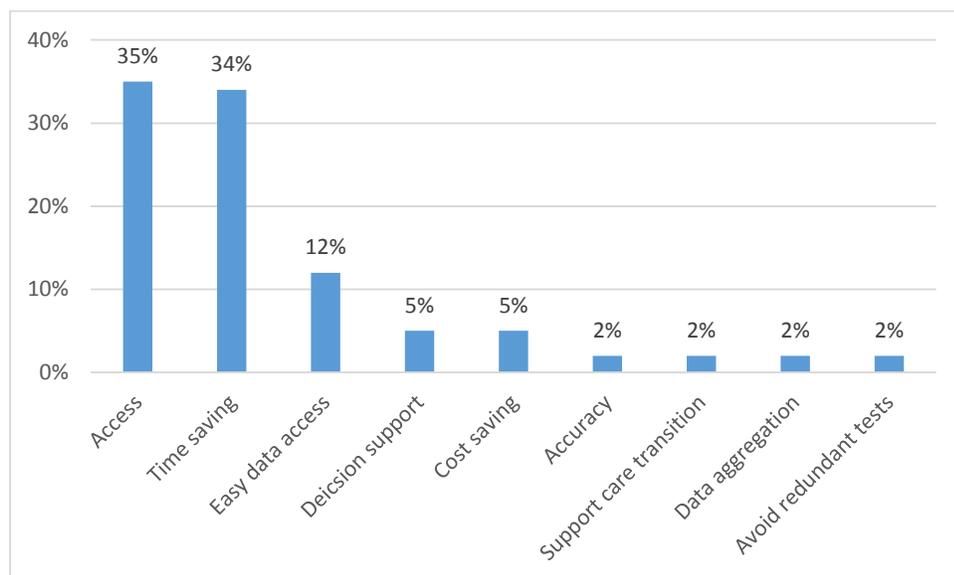


Figure 11. User reported benefits of CCHIE

In 2014, nine users (including 5 practice managers, 2 medical assistants, 1 nurse, and 1 technician) were interviewed regarding CCHIE usage in their practices. All of them identified access to external data as the most significant benefit of CCHIE. With the exception of two practices that used CCHIE solely for billing purposes, the other seven practices used CCHIE for clinical purposes such as getting patient records, transcripts, lab reports, surgical notes, radiology reports, discharge summary, and other patient data. Two interviewees mentioned that sometimes the data from CCHIE is incomplete and the search function of CCHIE could be improved. Despite these concerns, all of the interviewees believed that CCHIE was useful and their job would be more difficult without it.

Conclusion

In summary, the results of this three-year study suggest that CCHIE has brought positive outcomes to the participating physician practices. The practices’ CCHIE usage level had been continuously increasing from 2012 to 2014. Most respondents believe that the CCHIE functions have provided great value to their practices, the positive outcomes are observable, the data provided by CCHIE is of high quality, and CCHIE is competent and trustworthy. Overall, they are highly satisfied with CCHIE. From 2012 to 2014, most of the outcome variables demonstrated a

healthy increasing trend. The heightened ratings of these variables represent the users' positive perceptions of and attitudes toward CCHIE, which will likely contribute to the continued usage of CCHIE in the practices.

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