FHIR-Compliant Health Data Exchange with API Mediation Using MuleSoft

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Abstract: The MuleSoft mediated by API is initiating critical data flows in the healthcare system. The MuleSoft platform connecting diverse systems is facilitating the critical data exchanges. The purpose of the study is to examine how API mediation using MuleSoft can provide advantages to FHIR-compliant health data exchange. The study is an explanatory design and uses both qualitative and quantitative data. The analysis reveals the advantages of API and FHIR in attaining interoperability in healthcare systems. The data exchange between different systems is paving the way for improved healthcare due to the better care coordination possible. However, the companies should use query language and specify the terminologies for enhanced results. The use of effective query language can ensure that accurate data of the patient is sourced.

Keywords: API in healthcare, FHIR compliance, FHIR standards in healthcare, API mediation using MuleSoft, API interoperability

I. INTRODUCTION

A. Background of the study

MuleSoft is a platform that connects different systems despite their different technologies. The MuleSoft is enabling the FHIR-compliant health data exchanges. The creation of Application Program Interfaces (API) acts as the mediator for the data flow between the different systems applying the FHIR standard. The exchanging of data across diverse systems is enhancing the real-time accessibility to patient information. Impactful decision-making is vital in healthcare. It depends on the access to reliable health data [1]. The FHIR with its API mediation using MuleSoft can significantly improve the health data exchange. The usefulness of data exchange with API using MuleSoft can significantly improve all healthcare processes.

B. Overview

There is huge complexity and diversity in healthcare data that also needs to be shared. The need for effective data sharing has led to the creation of APIs [2]. The APIs play a critical role in the secure and modular interoperable accessing of data from the different applications. Clinical research is being significantly benefitted by the use of API. MuleSoft is ensuring a comprehensive set of advantages when developing API. The MuleSoft ensures a combination of the tools required for designing, developing and managing API at one point.

Figure 1: The Efficiency Metrics of MuleSoft

(Source: [3])

The feature is aiding integrating systems together with high degrees of efficiency [3]. The reusing of integration of assets reducing the efforts and time needed for new integrations. This is one of the robust advantages when using diverse applications

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that should be integrated efficiently in complex systems. The efficiency metrics of MuleSoft is high determining its viability [***Refer to Figure 1***] [3].

C. Problem Statement

The FHIR-compliant exchange of data requires vital API mediation to accomplish the required interoperability. There is more knowledge needed on how the API-mediated MuleSoft can support the data exchanges needed. The FHIR plays a critical role in increasing the accessibility of data and ensuring viable outcomes [4]. The interoperability in healthcare using FHIR standards through MuleSoft can ensure widespread applications. The lack of scalability and flexibility of healthcare data is creating complexities. The use of API-mediated MuleSoft applications can lead to crucial results within healthcare. There can be more effective APIs applied in healthcare with the research done.

D. Objectives

The study is striving to accomplish the following objectives: 1) To assess how the FHIR-compliant health data exchange benefits the healthcare interoperability 2) To critically examine the impacts of API-mediated MuleSoft health data exchange on the interoperability 3) To identify the various steps for supporting the integration of MuleSoft in healthcare.

E. Scope and Significance

The scope of the study is to assess how the FHIR compliance is benefitting the healthcare interoperability requirements. The study examines how API mediated MuleSoft can improve the data exchange interoperability needed in FHIR standards. The steps for supporting the integration of MuleSoft within FHIR-compliant data will be analysed. Interoperability is recognised as one of the fundamental requirements for the successful adoption of Healthcare Information Systems [5]. The research will establish the standards for improved interoperability of health data exchange. There can be more effective APIs developed on understanding the value of MuleSoft. Further, the FHIR applied to data leading to improved results in terms of interoperability. The significance of the research lies in outlining the practises for interoperability that lead to improved patient-care. The knowledge derived will aid healthcare companies to develop enhanced models capable of delivering better decisions.

II. LITERATURE REVIEW

A. Technology used for patient-centred interoperability in healthcare

There is an ongoing demand for patient-centred interoperability within healthcare. The health data exchange needs to be patient-driven and patient-mediated to extract critical results. The infrastructure is increasing the demand for Application Program Interfaces that can deeply benefit the interoperability needed. Blockchain is being considered as one such technology that can strategically benefit healthcare [6]. The blockchain can improve interoperability in healthcare with the sharing, encryption and distribution.

The real-time data acquisition could be combined with FHIR to upload the real-time events. The use of API-enabled FHIR is ensuring real-time logging in and observation of critical data [7]. The Blockchain is being considered as one of the effective means for achieving interoperability in healthcare. The securing of a permissioned framework for effective data exchange is being accomplished with Blockchain.

B. Benefits of interoperability in healthcare

The healthcare industry is empowered with interoperability. The communication possible with the interoperability can save time and efforts. The time spent on manual entry of data and administrative tasks can

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significantly reduce on the interoperability. The API-mediated MuleSoft can increase the operational efficiency within healthcare. The interoperability is reducing the possibilities of duplicate clinical interventions including such as lab orders or imaging systems. There is access to relevant clinical data that will deeply benefit the overall healthcare system [6]. The key information will be acquired through it.

The FHIR integrated with real-time data can pave the way for critical care teams to prepare for any kind of emergency. The interoperability can yield the vital results needed [7]. Healthcare organisations are facing consistent pressures for reducing costs and ensuring quality care to their patients. The practices in healthcare are marked by flexible and diverse clinical processes that are triggering high risks and costs [8]. The interoperability driven by semantic logs can benefit the healthcare system. The data gathered in reduced time will diminish the high risks and costs associated with the process.

C. Using API-mediated MuleSoft in healthcare

The use of API in healthcare is paving the way for data exchanges and analysis between the different systems. The APIs are helping to create patient-faced portals and applications that are providing patients with access to health records. The clinicians are able to make informed decisions and provide improved care to the patients. The use of API is clearly benefitting the healthcare industry gathering the diverse data for patient care [9]. Healthcare is requiring to manage an immense volume of heterogeneous patient data. The data collection and mapping possible through APIs is ensuring the access to critical data. The data cleaning of the vast volumes of data is being attained with the API data gathering and mapping [9]. The healthcare industry struggling to manage huge quantities of data is attaining a tangible edge. The APIs in healthcare are streaming the workflow with the mapping of data from disparate points.

D. Steps for ascertaining interoperability in healthcare

The use of interoperability can yield crucial results across the healthcare domain. The interoperability in healthcare can be improved by the clear outlining of FHIR profiles [10]. The FHIR profiles that are rigorously validated for the syntax and structure can ensure flawless results. The terminology issues are one of the prime considerations when developing impact-driven FHIR systems in healthcare. Any kind of inconsistencies regarding the use of specific terms within healthcare can result in ineffective interoperable work models. The vendors should be involved in the procedure from the beginning. The vendors should map the internal identifiers with the standard terminology for effective extraction of data [10]. The structural and semantic mapping for the FHIR profile needs to be carefully carried out [11]. The healthcare companies seeking to implement interoperability need careful planning for successful implementation of FHIR processes.

III. METHODOLOGY

A. Research Design

The research is applying explanatory design to examine the API-mediated MuleSoft benefitting FHIR in healthcare. The explanatory design is elaborating the strategic coordination and communication benefitting patient care across the organisations. The explanatory design helps in linking cause and effect driving comprehension on the subject. The explanatory design is effective in identifying the practical guidelines needed for application [12]. The explanatory design is aiding to analyse the API mediation benefitting healthcare processes and data exchange pertaining to FHIR applications. The links between the key

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features of API enabling healthcare interoperability is being derived with the explanatory design. The practical guidelines to be followed for integrating MuleSoft ensuring FHIR compliance is being derived.

B. Data Collection

The research is collecting both qualitative and quantitative data in order to attain impactful results. The data is gathered from secondary sources offering rich insights on the subject. The charts, graphs and other relevant statistics are being collected from the secondary sources for the quantitative data. The graphs and charts are useful in summarising the counts and proportions within the data [13]. The trends of data and the quantitative inferences regarding applications of API is extracted. The qualitative data is extracted from industry reports, books and journal articles. The qualitative data facilitates the understanding of the impacts of API mediations. The FHIR compliances are possible with the API mediation using MuleSoft is inferred from the data.

C. Case Studies and Examples

Case Study I: Pfizer

The Pfizer makes use of APIs for ensuring better care to their patients. There are increasingly specialised APIs for treating various diseases. The commercial capabilities of Pfizer are improving significantly with the development of APIs. It can be noted how Pfizer has teamed with Ochsner Health System for the development of connected and innovative models for clinical trials. There has been reduced manual data entry and expectations of lowered costs. There is integration of data with clinical trials in order to reach crucial results. The FHIR data standards are being used by Pfizer to build models that are consistent and reliable.

Case Study II: NHS

NHS is making use of FHIR HL7 to attain a more integrated system of healthcare. NHS makes use of Health Connect is drawing on diverse components to develop an improved system. NHS making use of FHIR HL 7 to support the critical exchange of information [16]. There are improved aspects of interoperability especially in the context of child health being acquired by NHS. The use of Integrated Systems in NHS is helping them to deliver better quality of care with access to information. The clinical information being exchanged is paving the way for attaining critical results across the domain.

D. Evaluation Metrics

The study is making use evaluation metrics for measuring and assessing the collected data. The selection of relevant evaluation metrics is crucial for classifying the data and reaching outcomes [14]. The present study is making use of accuracy and precision to examine the assimilated data. The precision of the API mediation in data exchange is being studied. The accuracy of MuleSoft in being able to attain interoperability standards is being applied. The study evaluates the procedures for interoperable data exchange in gaining accurate outcomes. The leveraging of FHIR compliances leading to precise care for patients is being analysed in the current study.

IV. RESULTS

A. Data Presentation

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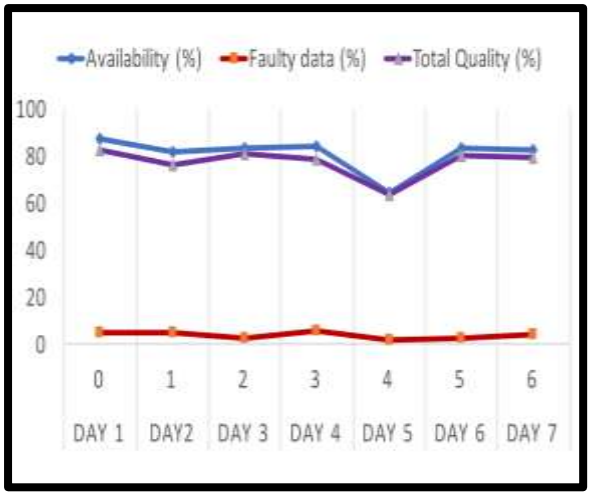

Figure 2: The impacts of API on data

(Source: [11])

The result for connected body weight scales using Taidoc can be noted on making use of API. The API mediation is increasing the data quality considerably indicating the viability of integrated systems. Data integration is helping to reach improved clarity in the domain of healthcare with its integration. The quality of data using APIs is increased to 80% while the data availability is measured at 90% [11]. The faulty data is minimised at 1%. The APIs are hence helping to attain increased visibility in the domain of body weight scales enabling to attain greater clarity.

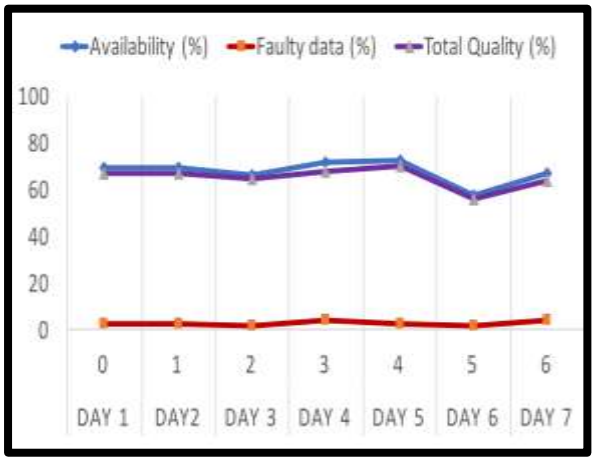

Figure 3: Impacts of API on FitBit Data

(Source: [11])

The bodyweight scales with the application of FitBit is gaining increased accuracy with the use of API. The data availability and total quality is assessed at 70% [11]. The faulty data is reduced to 0% indicating the flawlessness of API. The integration of data is helping to attain greater clarity. The systems need heterogeneous data and the use of API is paving the way for reliable results. There are more transparent results regarding the body weight scales enabling improved decision-making.

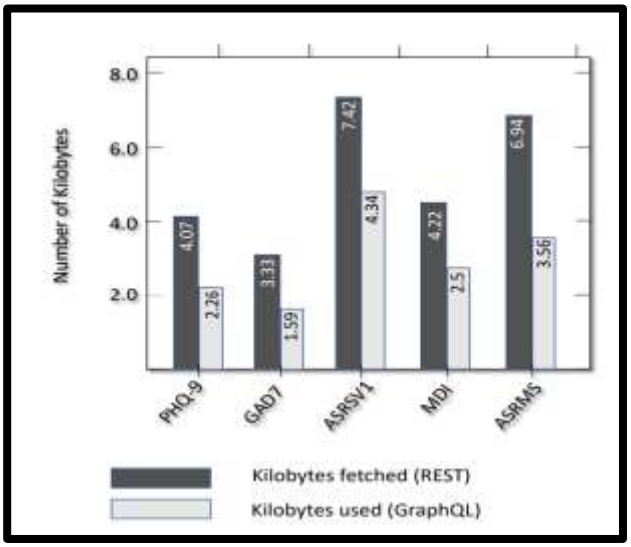

Figure 4: Redundant data fetched

(Source:[5])

The above figure reveals how the use of API can often result in the assimilation of redundant data. A 50% of the data fetched is used establishing the need for a focused approach in healthcare [5]. The API endpoints are ending up fetching a plethora of data that are having no relevance with the application. The endpoint allowing clients to make queries based on their specific requirements can support the application. The use of GraphQL as a query language can lead to cost-effective and flexible solutions meeting the client requirements.

B. Findings

The analysis shows how API-mediated applications can help in improving data quality and availability [11]. The API used for tracking body weight scales is able to reduce faulty data and increase the data quality. Also, the APIs can often have the

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weakness of fetching excess data [5]. The healthcare units can benefit from more focused programs that will allow clients to access the relevant data. The use of APIs with MuleSoft can deeply benefit the healthcare organisations aimed at delivering improved solutions. The application of effective query languages can lead to consistent and quality outcomes.

C. Case Study Outcomes

Case Study	***Strategy***	***Outcomes***	***Impacts***
Pfizer	Pfizer has teamed with Ochsner Health System to develop connected models [15]	There has been reduced data entry and time taken. The integration of data with clinical trials is leading to key decision-making [15]	The enhanced efficiency and better quality of patient care are the vital derivations from the study
NHS	NHS is making use of Health Connect to develop a more effective system.	The use of FHIR is paving the way for critical data exchange vital for improved care quality [16]	NHS is able to deliver better quality of care, especially in the context of child health with the integrated data available [16]

Table 1: The analysis of case studies

(Source: self-created)

The case studies are being analysed to understand how the use of APIs and FHIR are benefitting the healthcare processes. The analysis reveals how both NHS and Pfizer have been able to develop improved healthcare models with the applications. The use of API in FHIR compliance is enhancing the quality of care provided to students. The interoperability is also ensuring greater efficiency over the processes with a tangible decrease in time and effort.

D. Comparative Analysis

Journal	***Aim***	***Findings***	***Gap***
[2]	The comparative analysis of APIs across genomic data from multiple sources	The use of APIs can greatly improve genomics applications considering the interoperable data	The lack of discussion on the functionalities of API in healthcare
[4]	The vast improvement in the healthcare system using FHIR	A more evolved and patient-centric care is possible with the application of FHR	The development of improved care quality models
[6]	The use of blockchain in healthcare for	The blockchain facilitates the increased	No discussion on the steps for implementation

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	integrated systems	accessibility and data immutability needed	
[7]	The FHIR tools increasing the interoperability in healthcare	There are better responses to emergency situations with the FHIR tools	A lack of discussion on the drawbacks of using FHIR
[8]	The role of interoperability in the enhancement of FHIR	The analysis of event logs to attain stronger results.	There is no analysis of the interoperability challenges of implementation
[10]	The important steps for improved implementation of FHIR	The FHIR profiles need proper mapping with terminologies for reaching enhanced results.	The lack of primary data decreases the viability of the findings

Table 2: Comparative Analysis

(Source: self-created)

The above table analyses the various learning received from the existing literature. The analysis reveals how FHIR compliance and API are improving the interoperability of systems. The analysis is identifying how mapping with terminologies and interoperable standards is crucial to gaining the needed advantages.

V. DISCUSSION

A. Interpretation of Results

There is a huge importance of interoperability across the current healthcare systems [17]. The study reveals how the efficiency metrics of MuleSoft in integrating the data and creating interoperable processes are high [3]. The use of API in FHIR is driving salient benefits in terms of real-time logging in and the observation of data [7]. The use of API is strategic in collecting diverse data leading to patient-centric solutions [9]. The use of GraphQL for querying can reduce the time and effort needed for the healthcare processes. The results hence indicate how FHIR with its data exchange is aiding healthcare to provide better solutions. The API-mediated processes can provide tangible advantages to FHIR assimilating diverse sets of data. The mapping of terminologies in healthcare and the use of effective query language can solve the present issue.

B. Practical Implications

The accessing of clinical information is possible with the use of FHIR and API [18]. The analysis reveals how healthcare organisations can benefit through the access received to relevant data. The patient-centric information available can aid in reaching key decisions across healthcare. Organisations can gain advantages using API-mediated MuleSoft with its interoperability and flexibility standards [3]. Healthcare organisations require proper mapping to terminologies in order to attain improved results.

C. Challenges and Limitations

The APIs have certain challenges and limitations despite their advantages. There can be fetching of redundant data with the use of APIs in healthcare. The time and

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effort are significantly increased as a result [15]. The limitations can be overcome with the use of effective query languages. There can be relevant responses to the queries made facilitating improved outcomes.

D. Recommendations

There are important steps needed by healthcare organisations to apply API-mediated MuleSoft with FHIR standards. The employees need to be trained on the aspects of interoperability and how they can be attained. Further, the transitioning towards the new system requires careful consideration. The data cleansing and inputs to the new systems should be rigorously monitored.

VI. CONCLUSION AND FUTURE WORK

The research is revealing how API mediated MuleSoft and FHIR can greatly improve the interoperability needed in healthcare organisations. Healthcare organisations need interoperability to attain the needed standards of patient care. However, the analysis shows how there is a need for focused query language to yield improved results.

Future work should delve into the challenges of MuleSoft applications in healthcare. The frameworks that can overcome the challenges should be discussed to eradicate any errors. The work should concentrate on the query languages and controls needed.

VII. REFERENCE LIST

[1] Ismail, S., Alshmari, M., Qamar, U., Butt, W.H., Latif, K. and Ahmad, H.F., 2016, October. HL7 FHIR compliant data access model for maternal health information system. In *2016 IEEE 16th International Conference on Bioinformatics and Bioengineering (BIBE)* (pp. 51-56). IEEE.

[2] Swaminathan, R., Huang, Y., Moosavinasab, S., Buckley, R., Bartlett, C.W. and Lin, S.M., 2016. A review on genomics APIs. *Computational and Structural Biotechnology Journal*, *14*, pp.8-15.

[3] Singasani, T.R., 2019. Comparative Analysis of PEGA and MuleSoft: Efficiency, Scalability, and User Experience. *European Journal of Advances in Engineering and Technology*, *6*(3), pp.152-128.

[4] Braunstein, M.L., 2018. Healthcare in the age of interoperability: the promise of fast healthcare interoperability resources. *IEEE pulse*, *9*(6), pp.24-27.

[5] Mukhiya, S.K., Rabbi, F., Pun, V.K.I., Rutle, A. and Lamo, Y., 2019. A GraphQL approach to healthcare information exchange with HL7 FHIR. *Procedia Computer Science*, *160*, pp.338-345.

[6] Gordon, W.J. and Catalini, C., 2018. Blockchain technology for healthcare: facilitating the transition to patient-driven interoperability. *Computational and structural biotechnology journal*, *16*, pp.224-230.

[7] Walinjkar, A. and Woods, J., 2018. FHIR tools for healthcare interoperability. *Biomedical Journal of Scientific and Technical Research*, *9*(5).

[8] Detro, S.P., Morozov, D., Lezoche, M., Panetto, H., Santos, E.P. and Zdravkovic, M., 2016, February. Enhancing semantic interoperability in healthcare using semantic process mining. In *6th International Conference on Information Society and Techology, ICIST 2016* (Vol. 1, pp. 80-85).

[9] Mavrogiorgou, A., Kiourtis, A., Perakis, K., Miltiadou, D., Pitsios, S. and Kyriazis, D., 2019. Analyzing data and data sources towards a unified approach for ensuring end-to-end data and data sources quality in healthcare 4.0. *Computer methods and programs in biomedicine*, *181*, p.104967.

Doi:10.48047/ijiee.2020.10.4.6

[10] Matney, S.A., Heale, B., Hasley, S., Decker, E., Frederiksen, B., Davis, N., Langford, P., Ramey, N. and Huff, S.M., 2019. Lessons learned in creating interoperable fast healthcare interoperability resources profiles for large-scale public health programs. *Applied Clinical Informatics*, *10*(01), pp.087-095.

[11] Boussadi, A. and Zapletal, E., 2017. A fast healthcare interoperability resources (FHIR) layer implemented over i2b2. *BMC medical informatics and decision making*, *17*, pp.1-12.

[12] Subedi, D., 2016. Explanatory sequential mixed method design as the third research community of knowledge claim. *American Journal of Educational Research*, *4*(7), pp.570-577.

[13] Nuzzo, R.L., 2016. The box plots alternative for visualizing quantitative data. *PM&R*, *8*(3), pp.268-272.

[14] Hossin, M. and Sulaiman, M.N., 2015. A review on evaluation metrics for data classification evaluations. *International journal of data mining & knowledge management process*, *5*(2), p.1.

[15] Pfizer.com, 2019, *Ochsner Health System and Pfizer Partner to Develop Innovative Models for Clinical Trials*, Available at: https://www.pfizer.com/news/press-release/press-release-detail/ochsner_health_system_and_pfizer_partner_to_develop_innovative_models_for_clinical_trials [Accessed on: 5th December, 2019]

[16] DigitalHealth.net, 2019, *InterSystems makes FHIR tools free to NHS customers*, Available at: https://www.digitalhealth.net/2019/07/intersystems-makes-fhir-tools-free-nhs-customers/ [Accessed on: 15th November, 2019]

[17] Hong, N., Prodduturi, N., Wang, C. and Jiang, G., 2017. Shiny FHIR: an integrated framework leveraging Shiny R and HL7 FHIR to empower standards-based clinical data applications. *Studies in health technology and informatics*, *245*, p.868.

[18] Kamel, P.I. and Nagy, P.G., 2018. Patient-centered radiology with FHIR: an introduction to the use of FHIR to offer radiology a clinically integrated platform. *Journal of digital imaging*, *31*(3), pp.327-333.

[19] Yugandhar, M. B. D. (2020). Digital Operations in Fintech: A Study of Process Automation. International Journal of Information and Electronics Engineering, 10(4), 15-24.

[20] Chintale, P. (2020). Designing a secure self-onboarding system for internet customers using Google cloud SaaS framework. IJAR, 6(5), 482-487.

[21] Venna, S. R. (2019). Overcoming Submission Challenges in Post-Market Surveillance & Lifecycle Management. *Available at SSRN 5270737*.

Doi:10.48047/ijiee.2020.10.4.6