Service-Oriented Architecture for Real-Time Notification of Home Death Events and Integration

Robbinson C. Masinde
School of Computing & Informatics
University of Nairobi, Kenya.

Wanjiku J. Nganga
School of Computing & Informatics
University of Nairobi, Kenya.

ABSTRACT

The Births and Deaths Act of Kenya (Cap 149) mandates mandatory registrations of births and deaths. Registration of death events is crucial for setting and achieving the county's health goals. However, Kenya faces challenges of low death events registration, primarily home death events in rural areas which hinders seamless functioning of government agencies. Low registration of death events has been occasioned by difficult, manual and centralised processes in death events notification. This study addresses the challenges of low home death events registration by designing and developing a prototype that simplifies notification in rural areas and additionally simulates how this data can be shared. This research employed the Service-Oriented Design and Development Methodology to design and develop a real-time, user-friendly prototype that incorporates the USSD, mobile and web applications in notification, and REST API for integration. The key contribution of this study is enhancement of the present-day home death events notification process in rural areas by ensuring that notification service points are real-time and close to the registration agents. Additionally, the study shares death event reports with the relevant stakeholders.

General Terms

Software-Oriented Architecture; Distributed Computing Technology; REST APIs; Integration

Keywords

Software-Oriented Architecture; Real-time; Notification**;** Home Death Events**;** Integration.

1. INTRODUCTION

The death certificate is a legal document under the [1], providing for mandatory registration of births and death. Death events are registered by Civil Registration Services (CRS) after notification by the registration agents. Death certificate is crucial for accessing inheritance, proof of death, cleansing voter's register and taxpayer's register, and revelation of cause of death revelation vital in achieving the country's health goal. However, according to [2] Kenya faces challenges of low death registration, primarily home deaths in rural areas which hinders seamless functioning of government agencies. [3] rationalized that Civil Registration Services rely on Assistant Chiefs for death notifications but they sometimes send inaccurate and untimely data while [4] attributed low home death registrations to difficult and centralised process.

[5] averred that death registration process in Kenya is manual, hence doesn't capture events in real-time, and users are required to physically visit the Assistant Chief's office to notify events. [6] observed that registered death events in Kenya are not shared because of lack of mechanism to link registration, certification functions, check double registration, and integrate.

The aim of this study is to evaluate, examine and identify challenges of the current home death registration process in rural areas. The study additionally designs and develops a prototype that addresses the challenges of the current home death registration process in rural areas and simulates, using dummy data, how the prototype shares data through integration

This study will improve the current process of home death notification in rural areas by ensuring notification points are real-time and close to the registration agents/next-of-kin. Additionally, the study simulates how data can be integrated with relevant stakeholders.

2. LITERATURE REVIEW

[7] establishes that death event registration is essential for any country to set public health priorities and track progress in nationwide and world-wide targets. Nevertheless, data on death events statistics in developing countries has been unavailable, and if available, of limited usefulness because of untimeliness, execrable quality, incompleteness, and lack of integration with relevant organisations. The demands for data on mortality statistics have been met through analysing data on census, house-surveys, hospital facility information systems and mortality records counting. Conversely, these methods only offer short-term answers to the challenges of producing death event records that is satisfactorily dependable, opportune, and comprehensive to strengthen public healthiness solutions.

Whereas underdeveloped countries such as Kenya have challenges of death registration, literature from developed countries show robust online, real-time registration and integration [8]. Death event registration across the world show that low and middle-income countries have weak Civil Vital Registration Systems (CVRS) while developed countries have the best practises [2]. Additionally, the research detailed that for achievement of best practises, CVRS systems ought to be designed as business processes comprising notification, recording, registration and generation of data. The research further averred that developed countries such as Australia have implemented an enhanced coordination between different actors in death registration through integration. CVRS systems in Denmark reflects a good design architecture, security and integration. Moreover, Norway CVRS systems is updated in real-time and forms basis for tax, election, and public administration.

In the under-developing countries, research show that majority of deaths, especially in rural areas occur outside health facilities. According to [9], 53% of deaths in Kenya occur in health facilities while 47% were in the community. Death outside health facilities are rarely registered. The report detailed that death registration in Kajiado County was 28% of

the expected number. Tana River was 15%, Garissa and Wajir 9%, West Pokot 18%, Narok 19%, Homa bay and Migori at 24%. Urban areas like Mombasa and Nairobi recorded 88% and Nairobi 74% respectively.

Table 1: Expected vs. Registered Deaths in Kajiado County, as per the Kenya Vital Statistics Report 2023

Indicator	2018	2019	2020	2021	2022
Expected	7,089	8,836	9,042	9,755	10,067
Registered	1,866	1,692	2,213	3,026	2,829
Coverage (%)	26.3	19.1	24.4	31	28.1

Nevertheless, [10] observed that developing countries such as Bangladesh, Brazil, Albania, and the Philippines were using ICT to improve CVRS systems. [11] stated that CVRS system in India follows a model of decentralisation so as to incorporate citizens notifying events. Furthermore, the system is real-time, user friendly, detects double registration, generates death certificates and integrates with government agencies. In Albania, CVRS system integrates with other government agency systems. Citizen also obtains death certificates online. In Brazil, [12] established that Mortality Information System (SIM) reports deaths though limited by quality, coverage and information on causes of death.

In Africa, [13]and [14] found that South Africa and Ghana CVRS use the District Health Information System Software v2 (DHIS2) to register death events. DHIS2 is web-based real-time system, integrated with other systems and implements security measures. [15] observed that CVRS system in Rwanda is a web-based system with verification tool to verify events. According to [16] mobile phones are used to register home death events in Uganda.

Challenges in death registration can be categorized as administrative or technical challenges. Administrative challenges have been pointed out by [6] that include long distances to the Assistant Chief's office in rural areas and large number of people served by Civil Registration Officer (CRO). [17] indicated that some sub-locations in Kenya are large and that Assistant Chiefs also perform copious tasks and functions for the office of the president. Assistant Chiefs sometimes report death events twice leading to double registrations that is at place of occurrence and residence. Finally, Assistant Chiefs may occasionally lose death registration forms, [2].

In terms of technical challenges; [14] indicated that Kenyan Civil Registration Systems (CRS) don't integrate with other government systems. Additionally, [5] averred that Civil Registration Systems (CRS) in Kenya are not real-time while the [9] detailed that systems in place, essentially the eCitizen and CVRS system do not permit for death event notification, but application of death certificate.

[2] explains that Civil Registration of Vital Statistics (CRVS) systems comprise different business processes such as notification, recording, registration besides dissemination vital data. The business processes comprise of different data flows, artefacts, and applications. The report adds that CVRS system is an intravenous system and ought to be prudently designed to ensure the flow of data within and amid diverse information systems that encompasses the comprehensive CVRS.

[2] recommended that CVRS systems should be designed as business system that notify events in real-time and integrate with other relevant stakeholders. The study further added that there are developed nations and a few developing nations where low-and average-income countries can learn about the CRVS Systems

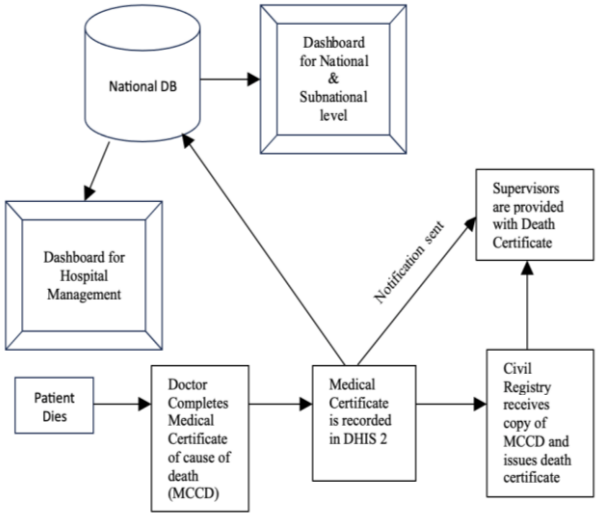


Fig 1: World Health Organization (2013) recommendation of CVRS System

The study consequently reviewed three software architectures for this purpose. Software architecture refers to how the software functions, scales-up and integrates [18]. The choice of a good architecture ensures better optimization of performance, scalability, deployment, reliability, and seamless running of applications.

[19] averred that monolithic software architecture components run as a single process hence limited fault tolerance. Additionally, the architecture is tightly coupled, difficult to modify and scale which may require the entire application to scale. Monolithic architecture also does not reuse components across enterprise and integrate.

[19] established that microservices architecture comprises of small services called microservices. Each microservice provides one part of the business logic. Microservices have emerged as new architectural to overcome challenges associated with SOA [20]. The scholar adds that architects are, nevertheless, reluctant to migrate from SOA to microservices. [21] adds that microservices are loosely coupled, agile, scalable, reusable and with high degree of cohesion.

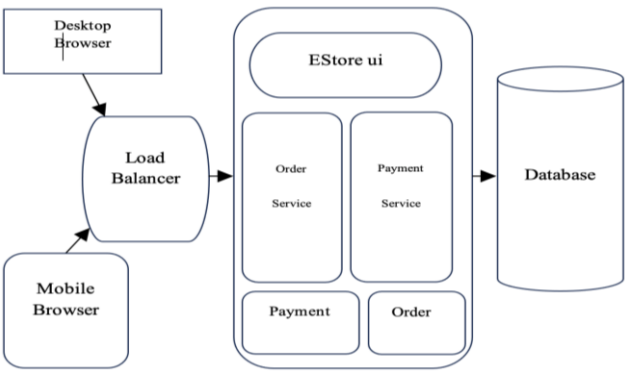


Fig 2: Siraj ul Haq (2018), Monolithic Architecture

Furthermore, Microservices have a high degree of cohesion. Application Programmable Interfaces (APIs) define how Microservices communicate in order to build distinct applications that execute a particular business logic function. However, each microservice require its own data storage and focus on independence than reusability.

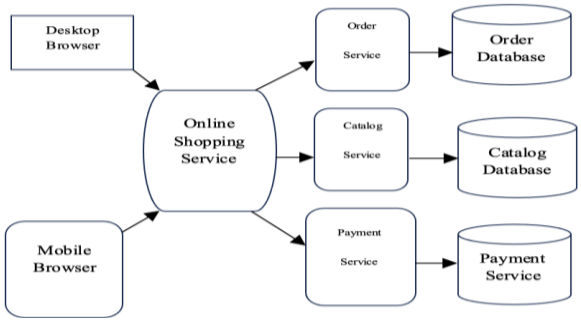


Fig 3: Siraj ul Haq (2018), Microservices architecture

Service Oriented Architecture (SOA) is a software architecture that delivers functionality as services that can be used and reused in other applications across the enterprise. Services communicates through the Enterprise Service Bus. [22] averred that SOA integrates seamlessly, enabling real-time updates. Conversely, the Enterprise Service Bus may be a single point of failure. Similarly, Services have a broad scope; hence failure of one service may affect entire workflow.

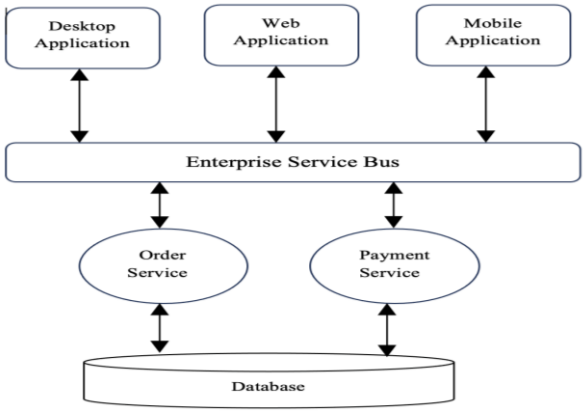


Fig 4: Sarwar (2020) Service-oriented Architecture

SOA is preferred to other architectures for its simplified data management as all services are connected to single data storage. [23] established that data consistence in SOA is straightforward, for services interact with a common data repository. Additionally, SOA is easy to integrate with monolithic and legacy systems compared to microservices and transaction management is also easy because services share a common repository. SOA is more mature than microservices with established tools, frameworks and protocols. Besides, SOA provides for reusability of services across the enterprise. Components in SOA are also course-grained unlike microservices where components are fine-grained.

From the literature reviewed, much work is yet to be accomplished in death event notification process. Death event registration is essential for setting country's public health priorities [7] hence the need to improve the notification process using ICT. [6] summaries that no mechanism has been established to link registration, certification functions, and sharing of data in Kenya while [4] averred that death registration process in Kenya is difficult and centralized. [24] observed that the death notification process is not real-time while [14] established that the current death registration systems in Kenya do not integrate death event statistics with other government agencies' data.

[25] explains that a conceptual model is an intermediate artefact for system construction. Conceptual design gives a schematic system description. The conceptual model below illustrates how home death events are notified directly to the Civil Registrar by the next-of-kin through a pre-notification service. The Assistant Chief physically confirms the events before verifying them. The prototype notifies the Civil Registration Department of home deaths in real time, check against double registration, and simulates how the data is shared

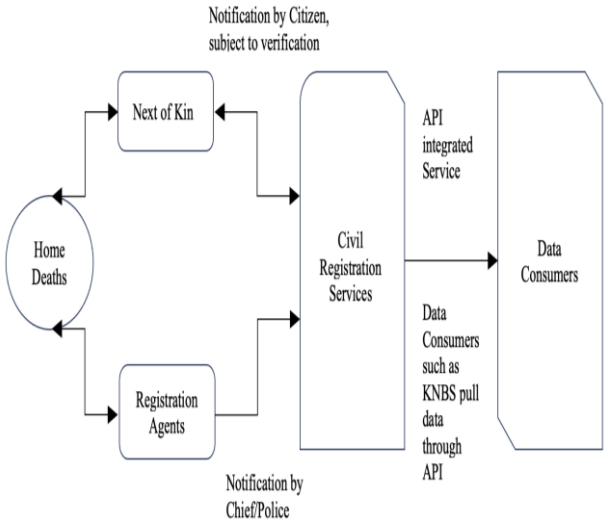


Fig 5: Conceptual Model

3. METHODOLOGY

The methodology was accomplished using [26] Service Oriented Design and Development Methodology that provide guidelines, principles, and techniques for establishment of productivity levels required by competitive business environments. The analysis of the data collected forms the footing for prototype requirements. The prototype requirements define the prototype design and development that addresses the gaps in the contemporary home death notification processes and consequently improve the notification of home death events.

The Methodology is designed on three main principles namely; service coupling, service cohesion and service granularity. The study objective on identifying challenges in the current process and examining it, were partly achieved in literature review. This section accomplished the objective on designing and developing the prototype that addresses challenges of the contemporarily process and integration. The service-oriented design and development methodology is founded on iterative and incremental process that encompasses: Planning, Analysis, Design, Construction, Testing, Provision, Deployment, Execution and Monitoring.

3.1 Planning Phase

This phase focus on understanding the prototype requirements. The study relied on two strategies, namely case study and the

survey. Explanatory case study is essential in qualitative research to enable gain a deeper comprehension of the current home death registration process in rural areas. Purposive/judgmental sampling was used to ensure only samples with problem knowledge are considered [27]. The participants for qualitative research comprised;

1. Assistant Chief, Mashuruu, Imaroro village
2. Civil Registration Officer, Kajiado
3. ICT officer, CRS
4. Head of Statistics, CRS
5. The Registrar General, CRS
6. ICT officer, KNBS

Cross-sectional survey facilitated quantitative research in Imaroro village, that involved investigating the community's views, attitudes, and experiences on home death registration. The sampling size for quantitative research was calculated using the [28], which gave a total of 384 participants. Imaroro Ward, Kajiado East in Kajido County, was chosen as the target population because of its remoteness and the nomadic habitation by the Maasai community.

The data collection method adopted was the sequential explanatory method. This method uses two dissimilar data collection time frames. Quantitative data is collected first then qualitative data. Qualitative data enhances quantitative findings. Qualitative data is collected by semi-structured interviews among the sampled participants while Quantitative data is collected from the sampled population in Imaroro, using questionnaires. Statistical Software IBM SPSS Statistics 29.0.1.0 was used to analyse quantitative data while the six-step framework analysed qualitative data [29].

[30] defines the response rate as the number of persons who have responded to the study divided by the total number of people sampled. Of the 384 questionnaires, 265 were reverted, representing a 69% response rate. In qualitative interviews, 5 out of the 6 were successfully and systematically conducted, giving a return rate of 83.3%.

The first objective evaluated the current system of death registration. The question sort to know where most death events occur. This study showed that 54.3% of all death events occurred at home, while 45.7% occurred in the health facility. The Registrar General's responded that most death events occur at home than hospital. He noted that emphasis seems to be on other systems than the death systems

Table 2: Responses on where death event occurs

		Frequency	%	Valid %	Cumulative %
Valid	Home	144	54.3	54.3	54.3
	Hospital	121	45.7	45.7	100.0
	Total	265	100.0	100.0	

Additionally, burial permits are not generated in real-time. 75.8% of respondents received death event notification slips in less than a week, while 24.2% received within a day.

Table 3: Responses on duration of death notification slips

		Frequency	%	Valid %	Cumulative %
Valid	1 day	64	24.2	24.2	24.2
	1 week	201	75.8	75.8	100.0
	Total	265	100	100.0	

Participants were asked on the effectiveness of notifying home deaths through the chiefs. 84.9% found the process not effective,10.2% found it effective while 3.4% were not sure. The chiefs noted that the process is manual, involving filling of forms, D2. The forms are then transported to Nairobi once every month

Table 4: Responses on notifying death through Ass. chiefs

		Frequency	%	Valid %	Cumulative %
Valid	Effective	27	10.2	10.3	10.3
	Not effective	225	84.9	86.2	96.6
	Not sure	9	3.4	3.4	100.0
	Total	261	98.5	100.0	

Additionally, respondents were asked on whether automation of the process will improve it. A total of 81.1% of the respondents would consider the new ICT technology, while 16.6% were not sure

Table 5: Responses on automating the current process

		Frequency	%	Valid %	Cumulative %
Valid	Yes	215	81.1	82.7	82.7
	No	1	.4	.4	83.1
	Not sure	44	16.6	16.9	100.0
	Total	260	98.1	100.0	

Finally, the participants were asked on the most preferred ICT technology. 32.1% preferred the USSD, while 37% preferred mobile Application. Respondents, totalling 15.8%, preferred the Web Application, while 13.2% were unsure. The ICT officer from CRS elaborated that all technologies are decisive because they would fit the different user needs

Table 6: Responses on the most preferred technology

		Frequency	%	Valid %	Cumulative %
Valid	USSD	85	32.1	32.7	32.7
	Mobile App	98	37.0	37.7	70.4
	Web App	42	15.8	16.2	86.5
	Not sure	35	13.2	13.5	100.0
	Total	260	98.1	100.0	

The second objective studied the challenges in the current processes of death registration. Participants were asked to give their views on the current home death registration process.

86.4%, thought the process was multifaceted, while 4.9% felt the process was easy. A further 7.2% were unsure.

Table 7: Responses on the current process

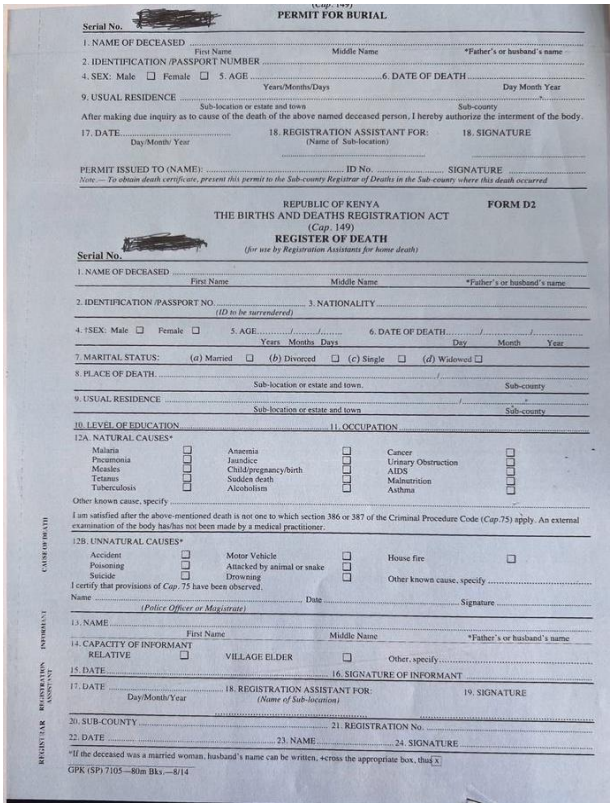
		Frequency	%	Valid %	Cumulative %
Valid	Easy	13	4.9	5.0	5.0
	Difficult	229	86.4	87.7	92.7
	Not sure	19	7.2	7.3	100.0
	Total	261	98.5	100.0	

The study observed that the contemporary process of home death event notification is manual and not real-time. The home deaths are captured in the registers by the Assistant Chiefs and sent manually hundreds of kilometres away to CRS Headquarters at the ACK Bishop House in Upper Hill Nairobi. The Assistant Chief uses the D2 forms to notify community home death events. The form is submitted by the 15th of every month.

3.2 Analysis Phase

In this phase, [26] establishes that the existing manual processes in the home death notification are transformed into business processes using the Service-Oriented Design and Development Methodology. Manual processes identified are outlined below;

1. Manual notification of death event by Assistant Chief
2. Verification of the death event by Assistant Chief
3. Provision of notification slip to the next-of-kin
4. Compiling of manual registers for manual transmission to the CRS Headquarters.
5. Registration of event by the CRS Department
6. Death certificate application by the next-of-kin
7. Submission of ID and burial permit of deceased during death certificate application
8. Payment of death certificates fee.
9. processing of death certificates
10. Provision of death certificates to the next-of-kin after submission off certified Identity Card
11. Requests of data by relevant stakeholders
12. Approval of the death event requests by Registrar General
13. Sharing of data by the Civil Registration Services



PERMIT FOR BURIAL

Serial No.

1. NAME OF DECEASED ..... First Name Middle Name *Father's or husband's name

2. IDENTIFICATION /PASSPORT NUMBER .....

4. SEX: Male ☐ Female ☐ 5. AGE ..... Years/Months/Days 6. DATE OF DEATH ..... Day Month Year

9. USUAL RESIDENCE ..... Sub-location or estate and town Sub-county

After making due inquiry as to cause of the death of the above named deceased person, I hereby authorize the interment of the body.

17. DATE ..... Day/Month/ Year 18. REGISTRATION ASSISTANT FOR: (Name of Sub-location) 18. SIGNATURE

PERMIT ISSUED TO (NAME): ..... ID No. ..... SIGNATURE .....

Note.— To obtain death certificate, present this permit to the Sub-county Registrar of Deaths in the Sub-county where this death occurred

REPUBLIC OF KENYA FORM D2

THE BIRTHS AND DEATHS REGISTRATION ACT

(*Cap.* 149)

REGISTER OF DEATH

(for use by Registration Assistants for home death)

Serial No.

1. NAME OF DECEASED ..... First Name Middle Name *Father's or husband's name

2. IDENTIFICATION /PASSPORT NO. ..... 3. NATIONALITY .....
(ID to be surrendered)

4. †SEX: Male ☐ Female ☐ 5. AGE ...../...../..... Years Months Days 6. DATE OF DEATH...../...../..... Day Month Year

7. MARITAL STATUS: (*a*) Married ☐ (*b*) Divorced ☐ (*c*) Single ☐ (*d*) Widowed ☐

8. PLACE OF DEATH ..... Sub-location or estate and town. Sub-county

9. USUAL RESIDENCE ..... Sub-location or estate and town Sub-county

10. LEVEL OF EDUCATION ..... 11. OCCUPATION .....

CAUSE OF DEATH

12A. NATURAL CAUSES*

Malaria	☐	Anaemia	☐	Cancer	☐
Pneumonia	☐	Jaundice	☐	Urinary Obstruction	☐
Measles	☐	Child/pregnancy/birth	☐	AIDS	☐
Tetanus	☐	Sudden death	☐	Malnutrition	☐
Tuberculosis	☐	Alcoholism	☐	Asthma	☐

Other known cause, specify .....

I am satisfied after the above-mentioned death is not one to which section 386 or 387 of the Criminal Procedure Code (*Cap.*75) apply. An external examination of the body has/has not been made by a medical practitioner.

12B. UNNATURAL CAUSES*

Accident	☐	Motor Vehicle	☐	House fire	☐
Poisoning	☐	Attacked by animal or snake	☐		
Suicide	☐	Drowning	☐	Other known cause, specify	

I certify that provisions of *Cap.* 75 have been observed.

Name ..... Date ..... Signature .....
(Police Officer or Magistrate)

INFORMANT

13. NAME ..... First Name Middle Name *Father's or husband's name

14. CAPACITY OF INFORMANT

RELATIVE ☐ VILLAGE ELDER ☐ Other, specify .....

15. DATE ..... 16. SIGNATURE OF INFORMANT .....

REGISTRAR REGISTRATION ASSISTANT

17. DATE ..... Day/Month/Year 18. REGISTRATION ASSISTANT FOR: *(Name of Sub-location)* 19. SIGNATURE

20. SUB-COUNTY ..... 21. REGISTRATION No. .....

22. DATE ..... 23. NAME ..... 24. SIGNATURE .....

*If the deceased was a married woman, husband's name can be written, across the appropriate box, thus x

GPK (SP) 7105 —80m Bks.—8/14

Fig 6: Form D2 from CRS department, Kenya.

The manual processes were replaced with the following SOA processes;

1. Notification services
    a) Pre-notification by Next-of-kin
    b) Notification by Registration Agents
    c) Acknowledgements of send requests by CRS
    d) Viewing status of reported events by Registration Agents/next-of-kin
2. Verification services
    a) Verification of users by CVRS department
    b) Verification/rejection of pre-notified events by next-of-kin
    c) Viewing notification status
    d) Generation/printing of death notification slips
3. Approving services
    a) Uploading certified burial permit of deceased during death certificate application
    b) Uploading of certified ID card of the deceased during death certificate application
    c) Surrendering certified ID of deceased to the Assistant Chief
    d) Viewing status of approved death certificate/reports on by CRS
    e) Generation and printing of approved death certificates
    f) Approving users by CRS
4. Data consumer services
    a) Exporting reports by relevant stakeholders
5. Administrator services
    a) Registration of Assistant Chiefs, relevant stakeholders and locations

b) Generation/printing of reports

6. Integration services
   a) Sharing of reports

3.3 Service Design Phase

The analysed processes were well-modelled and defined before construction [26]. The next-of-kin, police and Assistant Chief notify home death events. The burial permit is generated after Assistant Chief verifies event and next-of-kin uploads his certified ID and the deceased certified ID. Death certificates are generated once next-of-kin uploads his certified ID, burial permit slip, certified deceased ID and submits deceased certified ID to the Assistant Chief's

3.4 Service Construction Phase

[26] the designed services are transformed into interfaces that can be reused across the Civil Registration Services (CRS). The Web, Mobile and USSD have a PHP backend and MySQL 5.5 database running on the Cpanel web Server. Restful web services use REST APIs to communicate. REST APIs send HTTP requests. Web services are accessed using the HTTP requests. RESTful API Endpoints allow users to customise their requests with parameters to retrieve specific data.

[31] asserts that REST APIs are simple and standardised, scalable and support high performance because they are cacheable (responses from the APIs can be stored/cached by intermediaries such as the web browser for a period, allowing subsequent requests for the same resource to be fulfilled from the cache instead of the server resulting to faster responses). REST API communicates by JavaScript Object Notation (JSON). JSON is a simple and lightweight option compared to XML due to its small size and ease of reading and implementation. Many languages have libraries and built-in functions that pass JSON strings into objects/classes in that language.

The prototype is branded Real Time Death Registration System (RTDRS). The Assistant Chief physically confirms deaths in the field before verifying them. The Civil Services approves death events after relevant documents are uploaded. The system picks the "logged in" person as informant. When an ID/Birth Certificate number is entered, the prototype generates the name, calculates age, and gender of the deceased as per ID details in database, improving usability and friendliness. The prototype can also detect double registration. Additionally, the prototype shares events with stakeholders after passing token and credentials. The informants can view status of the death event on "registration status" tab that is, whether verified, approved or rejected. Furthermore, the prototype generates reports on death events.

The Web, Mobile and USSD define the different processes/functions of the prototype. The web services interfaces provide the server's backend services to the user.

The Real Time Death Registration prototype processes vital statistics considered sensitive therefore implementing confidentiality, integrity and availability is crucial. Authentication involves, Users sign up using valid ID numbers. The prototype checks against the strength of the password to control against brute force and dictionary attacks. Authentication in API is achieved by users passing valid "ClientID" and "client secret" after which "access token" is generated and used to make requests on the API endpoints.

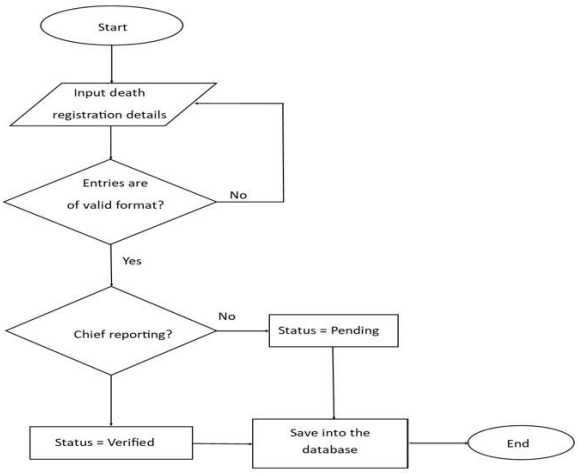


Fig 7: Process capture of death events flowcharts

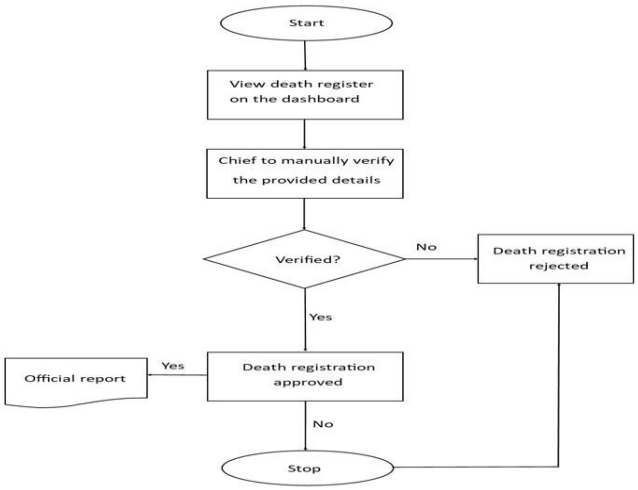


Fig 8: Verification flowcharts

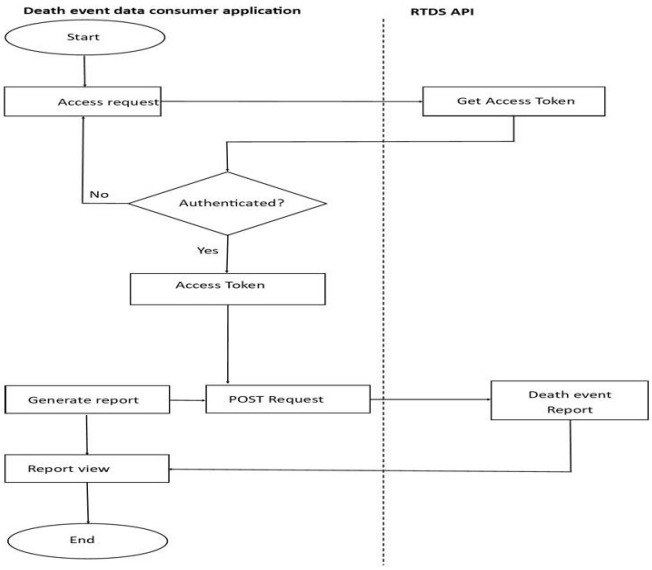


Fig 9: API Flowchart

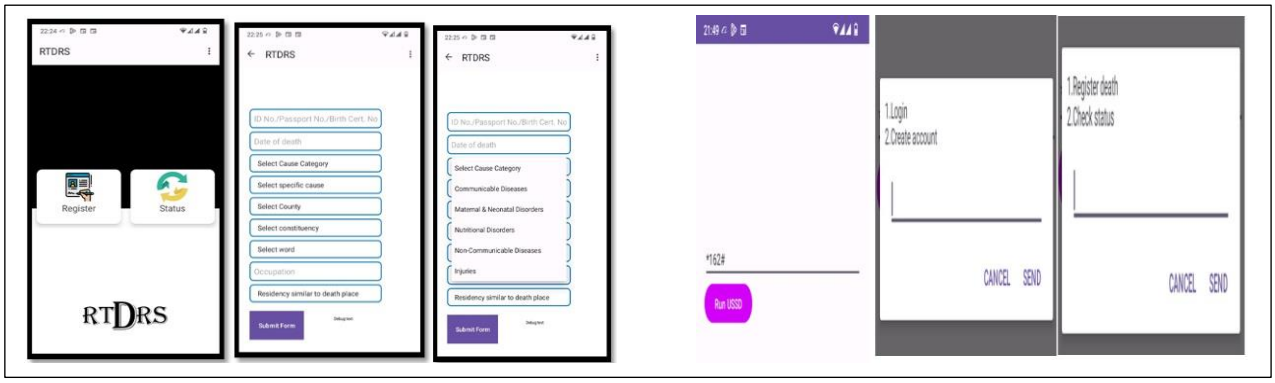


Fig 10: USSD and Mobile Application Login interfaces

Fig 11. Web Application interface as per the D2 form

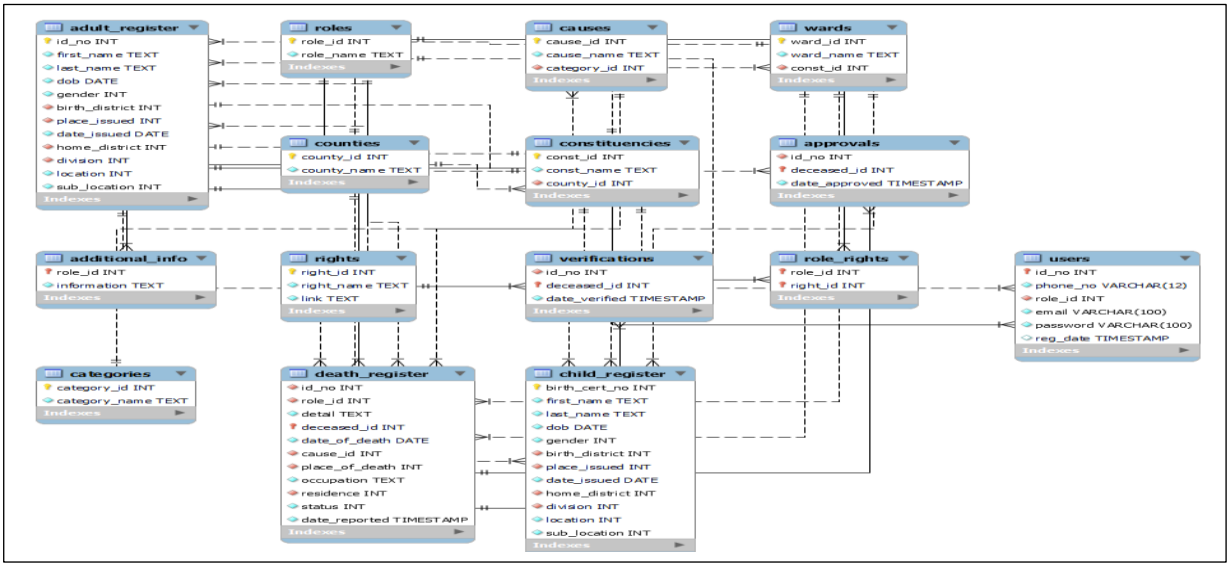


Figure 12: Entity Relationship Diagram

[32] established that to be authorised, one first needs to be authenticated since permission mandates: who, what, and which. Additionally, permissions are real-time attributes for controlling access and permission to protected resources. While authentication determines valid users, authorisation gives permission on safeguarded resources. The RTDRS enforces authorisation through Role Based Access Control (RBAC), whereby permissions are assigned to roles, and users are then assigned to suitable roles. Every role entails a set of permissions that define actions users can perform.

[33] averred that the drive behind encryption is to warrant that sensitive data remains confidential from unauthorised access. User passwords have been converted into a fixed-length string of characters by applying a hash function to the passwords referred to as hashing using SHA 256. Encryption on the network is achieved by Secure Socket Layer (SSL) certificate.

The prototype enforces input validation on the backend by server-side validation, data type validation and jQuery validation plugins. Additionally, the RTDRS protects user data from cross-site scripting through proper input validation and escaping techniques. Escaping prevents XSS attacks by encoding/escaping special characters that the browser could otherwise interpret as code.

3.5 Testing Phase

[26] established that dynamic testing, runs system implementations and comparing performance to the expected behaviour before deployment, this included; service authentication testing, service input validation testing, service request testing and test response time testing

3.6 Service Provision Phase

[26] averred that service provision encompasses service governance; services are reviewed whether they conform to government policies and privacy. Central service governance is chosen over distributed governance as services are managed at Civil Services.

3.7 Service Deployment Phase

[26] stated that Service deployment embodies rolling out the system for users' consumption. The prototype is hosted on

https://goodtimesolutions.co.ke/cpanel. The services are published using RESTful web services. Service orchestration is such that services are independent but integrated. jQuery mobile, HTML 5 and CSS standards support data integration while API endpoint returns data in JSON fostering interoperability. Access token is generated by executing the API endpoint below using POST method and passing the credentials. The Access token is used to generate data consumer reports

https://goodtimesolutions.co.ke/rtdrs/oauth2/token.php

```
{
   "grant_type": "client_credentials",
   "client_id": "ID",
   "client_secret": "PASSWORD
}
```

Generating reports is by invoking the POST method using the API endpoint below, Inputting access token generated and specifying parameters
https://goodtimesolutions.co.ke/rtdrs/api/reports.php

3.8 Service Execution Phase

[26] established that in this phase, web services are fully deployed, operational and service requestor can find the definition of service and invoke all defined service operations. Registration agents/Next-of-kin successfully registered events. Notification slips and death certificates were generated after verifications and approvals while data consumers generated reports

3.9 Service Monitoring Phase

[26] affirmed that service monitoring phase encompasses monitoring and improvement of the prototype to meet objectives. User acceptance testing was conducted as part of service monitoring which verifies in the user environment that the prototype fulfils user requirements. User acceptance testing was implemented in two phases, alpha and beta testing.

Alpha testing validated the system with thirty (30) closed data participants that functionalities are running as designed, resolved coding errors bypassed during technical testing, verified user friendliness, prototype fault tolerance and load testing not to mention participant feedback on confusing features.

Beta testing checked with thirty (30) open data participants that the prototype met the project objectives.

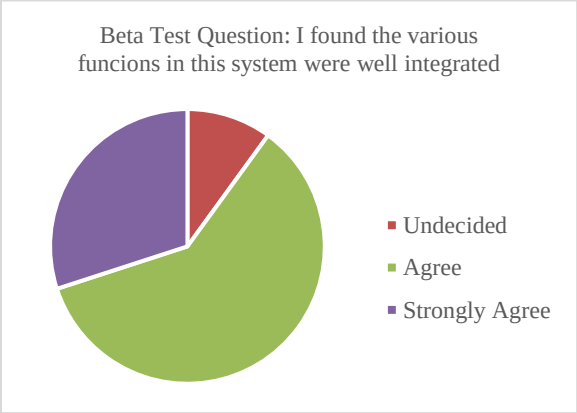


Fig 13: Beta testing question on how the participants found the system.

4. CONCLUSION

The goal of this study was to examine the current home death registration process in rural areas. Assistant Chiefs receive event notifications and records them in form D2 for physical transmission to the Civil Registry headquarters by 15th of every month. Another objective was to ascertain the challenges of the current process. The process is manual and doesn't integrate with relevant stakeholders. Finally, the study aimed at designing and developing a prototype that addresses challenges of the current process and simulating integration with stakeholders. This was accomplished by Service Oriented Design and Development methodology by [26]Papazoglou (2006).

The primary contribution of this study is to improve the existing manual process by ensuring notification service points are real-time and close to the Assistant Chief and next-of-kin by designing and developing a prototype that incorporates the USSD, mobile and web applications for notification. Additionally, the prototype shares reports with relevant

stakeholders through integration. The secondary contribution is growing scholarly literature on civil and vital.

While the prototype streamlines and simplifies the death event notification process by alerting the Assistant Chief in real-time on death events and Civil Registration Services Department, the Assistant Chief, is the only registration agent for home death events. The Assistant Chief executes a wide range of administrative tasks for the office of the President in a sub-location, and sometimes death registration may not be a priority [17]. This limits death event notification and consequently the need to incorporate the next-of-kin in notifying death events as recommended by the [2]. Additionally, mischievous individuals may forge identification numbers and register events.

A future study should focus on designing a legal framework for on boarding the next-of-kin as a registration agent. Additionally, the study ought to explore a technique that will determine the quality of data on death notification in terms of completeness, accuracy, timeliness and detect errors in the system essentially on phoney.

5. REFERENCES

[1] N. C. f. L. Reporting, "Births and Deaths Registration Act.," 2012.

[2] W. H. Organization, "Civil Registration and Vital Statistics 2013: challenges, best practice and design principles for modern systems.," 2013.

[3] UNICEF, "CRVSID Case Studies Kenya," 2013.

[4] D. Kweyu, " A death certificate could be your lifelineitle.," *Daily Nation.* , 2013.

[5] "[21] MEASURE Evaluation PIMA. (2017). Civil Registration and vital statistics system: End-of-project assessment".

[6] Y. Zewoldi, " Snapshot of civil registration and vital registration statistics systems of Kenya.," 2019.

[7] (. World Health Organization, ". (2015). Health and the Millennium Development Goals.," 2015.

[8] W. H. Organization, "Improving mortality statistics through civil registration and vital statistics systems. Strategies for country and partner support. Technical Meeting, November 4-5, Chateau de Penthes, November, 4–5," pp. 4-5, 2014.

[9] (. Civil Registration Services, "Kenya vital statistics report 2022.," 2023.

[10] CRVS-ESEC., "Current state of crvs: CRVS Innovations Conference," 2018.

[11] G. C. Mamta, "Estimating mortality using data from civil registration: A cross-sectional study in India.," 2015.

[12] A. L. C. Rinaldo Macedo de Morais, "An evaluation of the Brazilian Mortality Information System," *Research Gates,* 2017.

[13] R. Maluleke, "South Africa ’ s progress in civil registration.," 2019.

[14] U. N. E. C. f. Africa, "Practical Guide on the Improvement of Death Registration and Causes of Death Processes within Civil Registration and Vital Statistics System," 2017.

[15] N. I. o. S. o. R. N. I. A. M. o. L. G. M. o. H. M. o. &. M. o. G. a. F. P. K. Justice, "Rwanda civil registration and vital statistics systems," 2016.

[16] Uganda Govenment, " NIRA uganda mobile VRS. NIRA Uganda mobile VRS," 2020.

[17] B. Peter, "Birth notification service for civil registration In Kenya – SOA Model.," 2016.

[18] Y. Luchaninov, "Web Application Architecture in 2024: Moving in the Right Direction. Web Application Architecture in 2024: Moving in the Right Direction.," 2024.

[19] W. Zabierowski., "The Comparison of Microservice and MonolithicArchitecture.," 2012.

[20] V. R. a. R. Sadam, "Performance and complexity comparison of service oriented architecture and microservices architecture.," 2021.

[21] A. P. Bhuyan, "Alternatives to SOA architecture (SOA)?," 2014.

[22] J. K. (. Gitau, "Service oriented architecture model for integration of e-government systems in kenya . A case study of the eCitizen portal in Kenya By Supervised by. November.," 2016.

[23] A. W. Services, "Whats the diffrence between SOA and Microservices.," 2024.

[24] M. E. PIMA, "Civil Registration and vital statistics system: End-of-project assessment," 2017.

[25] B. Thalheim, "Conceptual Modelling," 2016.

[26] M. P. V. d. H. W. J. Papazoglou, "Service-oriented design and development methodology," 2006.

[27] I. Etikan, "Sampling and sampling methods.," *Biometrics & Biostatistics International Journal,* 2017.

[28] W. G. (. Cochran, "Sampling techniques (3rd ed.).," *New York: John Wiley & Sons.,* 1997.

[29] M. M. &. B. Delahunt, "Doing a thematic analysis: A practical, step-by-step guide for learning and teaching scholars," 2017.

[30] J. E. Fincham, "Responses rate and responsiveness to surveys," 2008.

[31] A. M. Bekabil, "REST API Implementation with Flask-Python," 2014.

[32] S. E. Sharil Tumin, "A Closer Look at Authentication and Authorization Mechanisms for Web-based Applications," 2012.

[33] T. Olufohunsi, "DATA ENCRYPTION," 2019.

[34] S. T. S. Encheva, " A Closer Look at Authentication and Authorization Mechanisms for Web-based Applications".

[35] S. E. Sharil Tumin, "A Closer Look at Authentication and Authorization Mechanisms for Web-based Applications," 2012.