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Electronic Journal of Informatics

The Electronic Journal of Informatics provides a platform for academics and non-academics to publish their research work. It provides an avenue for promoting a scholarly culture through research and the exchange of ideas, experiences and insights for personal growth and professional development. The Journal is open for articles in areas including business and management, information and communications technology, mathematics and computing science, tourism and hospitality.

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Authors who contributed articles for publication in this volume of the Journal.

Information for contributors

Articles should be 3000 – 6000 words in length including the abstract and references. Research notes, book reviews and editorial should be 900 – 1500 words. A no-more than 100 words biographical note about the author should accompany the article. Full information for authors can be accessed at https://www.dwu.ac.pg/en/images/All_Attachements/FBI/e-Journals/E-Journal-guide-for-authors.pdf

Editorial note

Welcome to Volume 5 of the Electronic Journal of Informatics, which is an annual publication produced by the Faculty of Business and Informatics at the Divine Word University. Publication of this journal began in 2019 to promote research culture through intensified research and knowledge exchange from its contributors.

Fiona N'Drower explores photo-elicitation as an accompaniment in enhancing an Indigenous research method piloted in rural PNG. She discusses photographs being used during storytelling as a tool to increase the engagement of the storytellers.

Allan Sumb explores the role of traditional culture in promoting sustainable development in Sinsibai, Western Highlands Province, PNG. He examines cultural changes within the Sinsibai community using a qualitative research approach.

Joe Agavi examines health service delivery in the Middle Ramu District of Madang Province in PNG. He presents the factors that affect health service delivery and the need to address them to improve health indicators in the province.

Martin Daniel examines how the National Online Application System in PNG works and its advantages and integration with the National Online Selection System. It provides recommendations for the Department of Higher Education, Research, Science & Technology improvement and considerations for the future.

Kosley Wara presents the factors that can affect academic staff in research and publication in PNG universities using literature and personal experiences. He demonstrates the need to address these issues to improve the research and publication outputs.

Rodney Gunik discusses the applications of the Internet of Things wearable devices in healthcare. He shows that this can be a consideration for healthcare services in PNG. He presents the factors that motivate the use of these devices in healthcare in developing countries and an architecture suitable for healthcare in PNG.

Lakoa Fitina & Knox McKen discuss secret sharing schemes from topological spaces. A secret sharing scheme divides a secret into shares, and the shares are distributed to

participants, such that only authorized subsets of participants can reconstruct the secret when they combine their shares. They propose several schemes based on the partition of a topological space.

Hope that you find the articles interesting and informative.

Dr Martin Daniel (PhD)
Coordinator & Chief Editor
Electronic Journal of Informatics
Divine Word University

Using photo-elicitation to enhance indigenous research method

Fiona N'Drower

Abstract

This study explores photo-elicitation as an accompaniment in enhancing an Indigenous research method piloted in rural Papua New Guinea. It discusses photographs being used during storytelling as a tool to increase the engagement of the storytellers. They are able to visualize the point of discussion. An Indigenous method emphasizes respect for the participants and that, research should be about the participants and their concerns. It also encourages the participants to be co-creators of the research. Photo-elicitation helps to create a comfortable environment between the researcher and the participants as the focus is on the photograph, a common space for a dialogue between the researcher and the participants. Furthermore, photographs taken during fieldwork enable the researcher to be more connected to the community and persons being investigated, a reminder of the research journey. Hence, the researcher becomes passionate about the research and the purpose of an Indigenous research method is realized.

Keywords: Indigenous research method, photo-elicitation.

Introduction

This study explores photo-elicitation as a technique for enhancing an indigenous research method piloted in rural Papua New Guinea (PNG). It discusses photographs being used during storytelling interviews as a tool to increase the engagement of the participants and to help them visualize the point of discussion. An indigenous method emphasises respect for the participants and that research should be about the concerns of the participants. Photo-elicitation helps to create a comfortable environment as the focus is on the photograph, providing a common space for dialogue between the researcher and the participants. Photographs taken during fieldwork enabled the researcher to be more connected to the community and persons being investigated, acting as reminders of the research journey. Hence, the researcher becomes passionate about the research and the purpose of an indigenous research method is realized.

Literature Review

Indigenous research methodology (Smith, 1999: Smith, 2012: Wilson, 2001: Kovach, 2009) is a concept that allows Indigenous people to better express themselves by using a set of steps in gathering information/ knowledge, comprehending it and disseminating it according to their specific cultural expectations. The cultural context incorporates a set of values and protocols (Hornung 2013). Denzin & Lincoln (2008) describe the concept of the Indigenous research method as a medium to correct and bring to light the misrepresentations of Indigenous people by their colonial masters. The method should accommodate the Indigenous people's way of life and not be forced upon them, for instance, the art of storytelling as opposed to a formal question-and-answer scenario. Rosile, Boje, Carlon, Downs & Saylors (2013) assert that storytelling inquiry is especially rich as a vehicle to study

processes and material conditions within organisations. CBT can be classified as micro-organisations.

Humberstone (2004) states that current tourism knowledge is Eurocentric and argues that taking on board alternative perspectives is essential for tourism to allow for better understanding and recognition of the needs of host communities and their environmental contexts. Nielsen and Wilson (2012) also argue that there is a need for Indigenous people to shift from being spectators of tourism studies to contributors by driving research projects and their outcomes. Fullagar & Wilson (2012) suggest that it is essential to know that there are diverse ways of understanding the operation and effects of power and oppression. Tremblay and Wegner (2009) concluded that there is a need to use an indigenous research methodology to study tourism relating to non-Western cases. There needs to be a realisation that it is important to use mechanisms that will allow marginalised communities to confidently and comfortably share their experiences as they see fitting to their situation.

Going further Whitford & Ruhanen (2016) asked, after reviewing 403 published journal articles and seeking the perspectives of indigenous tourism researchers, what an appropriate research methodology in indigenous tourism research might be. The authors suggested (pg.11) that such a research methodology should;

- be guided by indigenous peoples, not the Academy,
- offer reciprocal research benefits,
- use more open and exploratory research approaches,
- be guided by a collaborative and participatory research approach, and
- involve two-way conversations and knowledge exchange.

Harper (2002) defines photo-elicitation as the insertion of photographs into a research interview. The use of photographs as argued by Van Auken, Frisvoll & Stewart (2010) breaks down the power relation between the researcher and participants, stimulates deep interviewing and promotes community participation in planning as the aspirations of the community can be visualized. Furthermore, photographs can be used as an ice breaker between the researcher and participant, Scarles (2010) and it also helps the participants to visualize the researcher's discussion. Ibanez (2004) points out that photographs act as a source of communication between the researcher and participants. Ibanez (2004) also suggested that researchers may use photographs to expand on their questions and their use can lessen the tension of being interviewed by distracting the participants from being too aware of the interview because their focus is directed to the photograph.

Banks (2007) noted that photo-elicitation as an aid in interviewing fosters exploration and extended responses, revelations and empowering interactions. Empowerment to the once colonized and allowing them the opportunity to tell their stories their way are the underlying fundamentals of an indigenous research methodology. Castleden & Garvin (2008) also used photographs in community-based participatory indigenous research. However, despite Castle & Garvin's (2008) study being participant-generated photographs as termed by Richard &

Lahman (2014) and the study in the discussion being researcher-generated photographs, Richard & Lahman (2014) both studies noted that participants were engaged in conversations as they were allowed to express themselves using the photographs.

Storytelling can be used as an avenue to allow indigenous people to express themselves seems compatible with the notions of using photo-elicitation in research as suggested by Banks (2007). Shaw, Brown & Bromiley (1998) commentated that storytelling allows people to express themselves meaningfully infused with emotions and can bridge the gap between cause and effect, Gabriel (2004). Sakat & Prideaux (2013) used storytelling as a technique to gather data in a similar CBT research in PNG. Other authors have employed the art of storytelling as a research tool in indigenous studies (Wilson, 2008: Kovach, 2009: Chilisa, 2012).

Rakic & Chambers (2012) argued that the incorporation of visual methods in tourism studies is becoming more common, citing several examples (Crouch *et al*. 2005; Crang, 1997; Urry, 2002; Selwyn, 1996; Jaworski & Pritchard, 2005). This is appropriate because tourism relies heavily on images as a medium for promotion. Different studies in tourism using visual mediums have been conducted to explore; elements of tourists' experiences (Cederholm, 2004), values and motivations of tourists (Hindley & Font, 2015), and the nature of images used to persuade tourist destination choice (Wang & Sparks, 2014). Despite this growth, Park and Kim (2018) have argued that there is still plenty of room for more visual research in tourism.

Methodology

This observation is part of a study carried out in four different provinces, Eastern Highlands, Chimbu, Jiwaka and Madang, in PNG. Eastern Highlands, Chimbu and Jiwaka are situated on the mainland of PNG while Madang is located along the coast of PNG and also shares its land border with Chimbu and Eastern Highlands. The study involved using an indigenous research method to explore the effectiveness of tourism at the village level. Twelve tourism-related enterprises in eight different communities/villages were visited for this study. The main instrument employed in collecting information from participants was storytelling. However, photographs of different community-based tourism settings from countries similar to PNG were shown to participants as an aid to complement storytelling and deeper thinking so their thoughts and aspirations could be more clearly communicated during the storytelling. The photographs were researcher-generated and labelled by Bogdan & Biklen (1992) as archival photographs found and used because they fit with the context of the research. One of the themes that guided the storytelling was "future plans", under which a topic discussed was the preferred type of future tourism development and whether they would like to add another feature to the existing tourism product. The following photographs/ images were shown to the interviewees, refer to Table 1: Photographs shown to participants.

Table 1: Photographs shown to participants

Photographs	**Label**	**Photographs preference by tourism community/site**
	Photograph A: Tourist attempting to weave, cultural demonstration	EHP1 CHM5 MAG2
	Photograph B: Bushing walking, nature	EHP1 EHP2 CHM3 CHM4
	Photograph C: Biking in the village, additional activity	JWK1
	Photograph D: Tree house, eco-tourism	
	Photograph E: Basic CBT setup, village stay	
	Photograph F: Advanced accommodation	EHP3 CHM1
	Photograph G: Resort	MAG1
	Photograph H: Cable line, rainforest tour	CHM4
	Photograph I: Canoeing	MAG1

Eastern Highlands Province

In a book titled, The Eastern Highlands by Uyassi (1990), Eastern Highlands was the first province in the highlands region of PNG to be contacted by Europeans and today it is considered the gateway to the highlands. The first official government post in the province by the colonisers was erected in 1932 at Kainantu. Then moved to Goroka the current provincial capital in 1946. The town is strategically built around the airport. The province just like the rest of PNG goes through two seasons in a year. The dry season is experienced from June to October while the wet season is from December to April with May and November considered as the transitional months. Eastern Highlands shares its land borders with four other provinces; Madang, Morobe, Chimbu and Gulf. Initially, two groups of people were the first to make contact with the Eastern Highlanders. The Lutherans were the first missionaries to set foot on Eastern Highlands in 1919 followed by gold prospectors in the 1920s. The province, similar to other highlands provinces builds traditional houses quite differently from the coastal provinces, the houses in the highlands consist of circular huts with earthen floors. There are eight districts in the province with each member representing each district in parliament and the person known as the governor representing the whole province. The province is also a tourism hub in PNG, home of the Asaro mud man, a tourist icon for the province and the home of the annual Gorokoa Show which attracts tourists from all over. Birdwatching and trekking are also being promoted http://www.papuanewguinea.travel/easternhighlands. The main agricultural crop exported is coffee as the province grows most of PNG's coffee. Communities visited in the Eastern Highlands were from the Daulo District and from within the Lower Asaro Rural local level government (LLG).

Chimbu

Outsiders namely the missionaries, gold prospectors and local carriers from the coastal parts of PNG continued to penetrate further into the unknown interior of PNG from the Eastern Highlands. The end of WWI saw the Australians take control of German New Guinea, Papua was considered to be more established by Great Britain than Australia. The Australian Mandate Territory of New Guinea Administration was responsible to the League of Nations for a territory partly explored by Brown (1995, pg35). This promoted the administration to continue to explore and set up administrative posts in the rest of PNG. Chimbu (Simbu) became a province of its own after separating from the Eastern Highlands on 7th July 1966, having its own administration. Chimbu as described by Brown (1995) is a place situated along mountain valleys and cultivated the mountain slopes for survival. There are six districts in Chimbu with seven elected members representing the province in parliament. Kundiawa-Gembogl was the district visited for this research. The district is the largest in Chimbu in administrative matters as it consists of two districts. Kundiawa is where the provincial capital is located and is also known as Kundiawa. The district is situated northeast of the province and has four local level governments (LLG). Mitnande LLG is where participants for this research were sought from. Chimbu experienced its first contact with a non-Papua New Guinean in 1933. A German priest travelled from Madang to Chimbu making him the first White Man to be seen by the people of Gembogl https://simbuprovincialgovernmentblog.wordpress.com/kundiawagembogl/.

Chimbu is surrounded by Madang, Eastern Highlands and Gulf Province. Chimbu is also home to PNG's highest mountain, Mt. Wilhem rising at 4 509 metres above sea level. The mountain is situated within the Kundiawa-Gembogl district. At the foot of the mountain, there are guest houses, trekking facilitators and cultural demonstrators. PNGTPA suggests that activities such as trekking, mountain climbing and caving can be done in Chimbu. The province is known to have rugged mountain slopes that are almost inaccessible.

Jiwaka

Jiwaka became a separate identity from Western Highlands Province in 2012 (Zurenuoc & Herbert, 2017). The province has three districts. Anglimp - South Waghi District, the largest district in Jiwaka is where participants for this research were sought. The district is at the border of Western Highlands and Jiwaka. One of the participants claimed that the people of Anglimp speak Melpa, a language spoken by Western Highlanders and are traditionally, culturally and geographically identified with Western Highlands. The province exports tea, and coffee and relies on its people to maintain its economy. The province compared to other provinces is new and is slowly venturing into tourism. However, tourism activities are happening as it was once part of Western Highlands Province. Anglimp Rural was the LLG visited.

Madang

Madang as previously discussed is a maritime province and at the same time plays a crucial role in linking the coast to the highlands. Tourism is a common phrase in Madang as it dates back to the colonial days when expatriates residing in the province would travel around the province for leisure during their free time. Madang offers tourism activities from scuba diving to bird watching due to its geographical location. The first place to be visited for the research proudly told the story of Prince Phillip of Edinburgh visiting their island in 1971 and swimming in the sea. Madang unlike the other provinces has a long history of tourism.

Photographs

PNG Tourism Promotion Authority's (PNGTPA) website, https://www.papuanewguinea.travel/corporate-site, was identified as a point of reference in selecting the appropriate photographs (Tourism Promotion Authority, 2024b). The website recommends the following tourism activities that tourists can engage in while in PNG: birdwatching, cultural activities, scuba diving, cruising, fishing, kayaking, snorkelling, surfing and trekking (Tourism Promotion Authority, 2024a). The photographs were chosen in accordance with their similarities to the type of environment and the type of tourism being offered at the various communities visited for this study. All photographs are of tourism settings in various third-world countries similar to PNG.

Coding

The inclusion of photographs during storytelling encouraged the participants to elaborate on their responses. The conversations were recorded using a voice recorder, then translated into English and transcribed by the researcher. Each site visited was given a code consisting of

letters and a number. The letters represented the names of each of the provinces visited while the numbers represented the numerical order of the sites/communities visited within each of the provinces. Table 1: Photographs shown to participants, show not only the photographs but also the various sites/communities preferences of the photographs and how they would like their current tourism offerings to be in the future. Participants were asked why they chose a particular photograph; the responses were then separated into similarities of why they chose a particular photograph over other similar photographs.

Results

The first community visited in Eastern Highlands (EHP1) indicated photographs A and B as their preferred future. They would like to see tourists engaging more with the community by trying out such things as target shooting (using traditional bows and arrows), weaving bilums (over-the-shoulder bags) and making traditional ornaments. This supports the notion that tourism could benefit everyone if it is shared with other members of the community and not just the main tourism resource owners. To date in this community, only a few tourists have actually participated in activities with most, more interested in watching cultural performances in the form of traditional songs and dances. This community also, if requested, will do bush walks with tourists, however, they pointed out that the treks need to be done properly so it is fitting and more attractive for tourists. The second community visited (EHP2) opted for photograph B as it fitted with their current practice, trekking. While conversing with the interviewees it was realized that bushwalking, trekking and mountain climbing were terms used interchangeably. The interviewees described the current trekking situation as risky and hazardous, mentioning that there are no proper railings to prevent tourists from falling. The track starts from the main road and leads to a cave, which holds traditional beliefs. The third tourism site to be visited also within Eastern Highlands (EHP3) was a locally owned husband and wife tourism tour operator, who presented themselves as an eco-tourism cultural centre. They shared their aspiration by discussing something similar to photograph F: Modern accommodation, but with traditional architect and elements to it.

In Chimbu, the first stopover was at a lodge (CHM1). The owner indicated that it would be nice to have electricity as shown in photograph F. As she suggests, the picture looks as if the place is situated somewhere in the forest which is the type of environment that surrounds her. However, the second place visited (CHM2), also a lodge owned by a family, shared that it would be nice to re-open the airstrip in the village so tourists could travel to them directly by air. The lodge seemed to already have the basic facilities in place to support tourism. The third tourism service provider (CHM3) was a family-owned business managed by a female family member providing trekking services. She instantly pointed to photograph B, saying the treks leading to Mt. Wilhem (the highest mountain in PNG) are in desperate need of maintenance and it would be nice to have proper walkways that will enhance the experience of tourists.

Figure 1: The photograph is of CHM2 (The second place visited in Chimbu)

While in Chimbu two other groups of people involved in tourism activities were invited to take part in the research including a family involved in lodging and trekking, one of the pioneers of tourism in the village (CHM4). Photograph B was indicated as their ideal facility for trekking while photograph F was marveled at as the long-term dream. This family also mentioned using a cable line as a way of conducting rainforest tours that could assist in preserving the environment and give people a better view of the natural environment. The last group was a cultural group (CHM5). Photograph A was chosen by this group who described it as appropriate for them as they have specifically set up cultural demonstrations so tourists can experience for themselves and participate in traditional activities. Currently, the group is focused on traditional dancing. The photograph was not the same as what was desired, but it stimulated the participants to express their longing for a specific spot in their community that would accommodate their needs in relation to providing tourism experiences to visitors.

Jiwaka was the next province to be visited after Chimbu. A Guest House combined with a cultural centre was the first point of call (JWK1). Again photographs B and F were chosen. Photograph B, according to the storytellers, looked more suitable for the kind of activity tourists indulge in, while photograph F looked more realistic for the type of environment they have. An additional activity that was identified to be later included is biking as illustrated by photograph C. The last stop in Jiwaka was another cultural centre (JWK2) owned by an individual who relies heavily on the community to keep the centre in operation. Photograph A was the closest image to his plan of offering immersive cultural experiences for tourists with proper facilities for tourists to relax while taking part.

Being a coastal province, Madang was different from the highlands provinces. An island known for hosting picnics and a swimming spot for tourists was of interest as it also has remnants of WWII (MAG1) (Nolan, 2017). The family here opted for something smaller than the resort portrayed in photograph G, one that is manageable and overlooks the sea. After sighting photograph I, it was indicated that it would be appealing to introduce kayaking as an added activity for tourists. The last place to be visited was also in Madang but located further inland from the coast. The village in previous years was active in tourism (MAG2).

International tourists would visit the community to experience the cultural demonstrations that occurred in the village. The experience included; traditional cooking, dancing and the production of artifacts. However, it's been almost twenty years since they've experienced tourism in their village. They blamed it on the lack of infrastructure such as having a sealed road and lack of commitment by the provincial tourism bureau. They saw Photograph A as similar to the type of tourism they can offer.

Photographs D and E were not considered by any of the participants from the four provinces visited. Photograph E was of a basic CBT in a village while photograph D was of tree-houses promoting eco-tourism. While the idea of eco-tourism is being embraced and considered by the participants, the concept of a tree house did not appeal to them. This could be attributed to the locals' perception of traditional architecture influenced by their cultural practices and tree-houses are not a common practice in PNG. Photograph E was of a basic CBT set up in a village, it was not chosen by the participants as a stimulus to discuss their plans as a lot of the participants identify with it as being the stage they are currently at.

Conclusion and discussion

Photo-elicitation not only can be used by the researcher to enhance the participation of the respondents but the researcher as well. Photographs taken during the research process also help the researcher to retain memories of what was said and done during data collection. Photographs of people and places create a sense of sincerity and appreciation by the researcher, this helps to create a lasting relationship between the researcher and the participants and gives personal meaning to the research (N'Drower, 2020). Not only are voices being heard but the faces and places that go with them, making the whole process visible, the intangible can be visualised giving the researcher a good grounding in the research. The photographs then become essential for the researcher to reflect upon to add value to the research notion, not only are thoughts being processed but these thoughts are deeply drawn from the researcher's intuitions and not just from responses being extracted by the research questions being asked. However, this may cause the researcher to be emotionally involved resulting in the interpretation of the data being biased. The researcher, therefore, must find a balance between his or her personal thoughts and feelings and the reality of the situation by critically looking at the findings before passing judgements.

The findings are not just based on intuitions, instincts and face value interpretations by the researcher but rather from the underlying desires, aspirations and thoughts projected either directly or indirectly through the storytelling and conversations between the researcher and participants. Hence, in the case of applying an indigenous research methodology as the epistemology, the research therefore becomes about the people, for the people and by the people.

Photo elicitation does enhance the interviewing process and, in this case, storytelling. It helps to turn illusions into realization, emphasizing the representation of people's ideas, views and what they desire for themselves (Harper, 2002). The storytelling and sharing of experiences and aspirations took place at the local level, involving members of the village/community

(ward level) which make up the districts in the provinces. Indeed, photo-elicitation could be used as a planning tool for tourism involving community participation at the various districts and can be channelled through the local level governments and institutionalized at the village level.

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Exploring the role of traditional culture in promoting sustainable development in Sinsibai, Western Highlands Province, Papua New Guinea

Allan Sumb

Abstract

The purpose of this study was to examine cultural changes within the Sinsibai community. A qualitative research approach was employed, using in-depth semi-structured interviews to gather the views of community members. Both focus group and one-on-one interviews were conducted, and purposive and snowball sampling techniques were used. Data were analyzed thematically. The findings revealed that the traditional culture of the people in Sinsibai, located in the Western Highlands Province, has experienced significant changes. While many positive cultural practices have been preserved, some traditions that were no longer beneficial to the community have been discarded. Notably, the introduction of Christianity and education has led to the cessation of tribal fighting in the village, contributing to over 70 years of peace. This has created opportunities for business, education, and agricultural development. A key strength of Sinsibai is its strong community leadership, with most conflicts being resolved by community leaders rather than relying on the police. However, despite the positive cultural changes, challenges remain in the community, particularly with the consumption of marijuana and alcohol by a small number of individuals.

Keywords: Culture, Christianity, traditional culture, Sinsibai

Introduction

Culture is a dynamic system of values comprised of learned elements such as assumptions, conventions, beliefs, and rules (Spencer-Oatey,2012; White,1959). These elements enable group members to interact with one another, engage with the world, communicate effectively, and express their creative potential (Spencer-Oatey,2012; White,1959). It encompasses various facets of life, including clothing, child-rearing practices, dietary habits, marriage traditions, political systems, religious beliefs, and death-related rituals (Spencer-Oatey,2012; White,1959). The strength of the Western Highlands Province (WHP) people lies in its land and the rich cultural values that have been passed down through generations. These cultural traditions help strengthen communities and families. Additionally, WHP has fertile land that is highly suitable for agriculture (Kitan, 2013).

Sinsibai village is located within the Mt. Giluwe Rural Local Level Government (LLG) of the Tambul-Nebilyer District in the Western Highlands Province (Gibbs et al., 2022). Situated approximately 30 kilometres southwest of Mt. Hagen, the village is accessible via a 50-minute drive. The community primarily relies on subsistence farming and small-scale commercial agriculture for their livelihood. Crops such as sweet potatoes are cultivated and transported to distant markets, generating modest incomes to meet basic needs like school fees, transportation, healthcare, and other essentials (Gibbs et al., 2022). The village is equipped with essential infrastructure, including a fully operational health centre and locally owned trucks that provide transport services to and from Mt. Hagen. Despite this, food

security is occasionally threatened by issues such as pests and frost. Educational institutions in the area include Sinsibai Primary School, Sinsibai Elementary School, and the recently established Upper-Nebilyer Secondary School. Most of the residents identify as Catholic, followed by members of the Seventh-day Adventist, Lutheran, and United churches, among others (Gibbs et al., 2022). This paper focuses on identifying the advantages of maintaining traditional culture while embracing post-change developments in the Sinisbai community.

Literature review

Importance of traditional culture

Culture is a dynamic system of learned values, encompassing assumptions, beliefs, and customs that shape the way of life for a specific ethnic group or community (Renteln, 2015; Spencer-Oatey, 2012; White, 1959). These beliefs and customs are important to maintain for future generations to know and understand culture (Greaves 1994; Spencer-Oatey, 2012). For instance, the future generation needs to know and understand the cultural practices, rituals, and languages. This helps communities to stay connected to their roots, fostering a strong sense of identity and contributing to a stable and cohesive societal fabric. This connection also enhances mental well-being and reinforces a sense of belonging (Greaves,1994; Spencer-Oatey, 2012).

In the Western Highlands Province of Papua New Guinea (PNG), traditional culture remains highly significant to the people. They continue to practice traditional customs such as paying bride price, gardening and resolving conflicts in the Melanesian way practices (Gibbs et al., 2022; McKenna et al., 2020). For example, if a conflict arises within the community, local leaders act as mediators to negotiate peace. Once both parties reach an agreement, harmony is restored. Despite the limited police presence, the community successfully maintains peace through these traditional practices (Gibbs et al., 2022; McKenna et al., 2020). In addition, one important aspect of everyday life in WHP is gardening which is practised by every person in the community. This is not a surprise that WHP is the birthplace of Agriculture as Kuk archeological site is found there and is more than 9000 years old (Ketan, 2013; Feil, 1987). In the past people lived as hunters and gathers but WHP were the first people to engage in agricultural activities by cultivating food crops and rearing pigs for protein and ceremonial activities (Feil, 1987). Pigs were important resources for the people of WHP. Pigs were used for bride price, traditional moka, feasts and other traditional activities (Feil, 1987; Watson 1977). In the province, pigs are widely raised by most families, though commercial piggeries are relatively rare. The current market rate for an average-sized pig is K1,000, while a fully grown boar can cost up to K3,000. While some pigs are sold annually to cover school fees, the majority are reserved for irregular events such as ceremonial exchanges, bride price payments, compensation settlements, election hospitality, and pig-centered ceremonies (Ketan, 2013).

Challenges of maintaining the traditional culture

Several influences change the attitude and behaviour of the people in the Western Highlands Province (Kitan, 2023). These changes include education, politics, improved government services such as roads, telecommunication services, electricity and health services and

Christianity (Gibbs et al.,2022; Kitan, 2023). For instance, village people have access to mobile phones. Some people use the phone and access the Internet for good purposes but others use it for accessing illicit materials. Moreover, some developments are positive and change the lives of people (Gibbs, et al.2022). In the Western Highlands Province, there is less or no tribal fighting which is a positive change that brings development and helps people to live peacefully among themselves (Gibbs et al., 2022). Similarly, (Kitan, 2023) most Western Highlanders embrace development and go into business, agriculture and education (Kitan, 2023). Furthermore, Christian is seen as a positive change in the community. In the past, tribal fights were frequent in the Western Highlands Province but not now because of strong community leadership and Christianity (Gibbs et al., 2022).

Furthermore, in most highlands provinces, conflicts predominantly arise from competition over resources such as land, women, and pigs (Weiner, 2002). Conflict is viewed as an unavoidable aspect of life, with no overarching authority to enforce laws across tribes, regions, and cultural groups (Weiner, 2002). In this power vacuum, physical violence is considered an acceptable form of punishment, particularly for repeat offenders. Offending parties may include individuals, clans, or entire tribes (Weiner, 2002). In the Western Highlands Province (WHP), such issues are often resolved amicably by village leaders (Gibbs et al., 2022; McKenna et al., 2020). This was supported by Ketan (2013), in Melanesia, the classic PNG Highlands big-man model encapsulates the essential features of good governance and problem-solving. Big-man status was earned through competitive success in ceremonial exchanges, maintained by carefully cultivating social relationships, and lost if exchange partners and followers were neglected (Ketan, 2013).

Despite strong community leadership and ongoing developments, communities in WHP still face significant challenges. The first challenge is politics, particularly during Local Level Government (LLG) and National General Elections (Gibbs et al., 2022; McKenna et al., 2020). Elections in WHP are often marked by heightened tribal violence, although tensions typically subside once the elections conclude. The second challenge involves the consumption of marijuana and alcohol. Intoxication frequently disrupts local communities, leading to social disturbances. The third challenge is prostitution, which has been linked to the widespread use of mobile phones. This has resulted in a rise in teenage pregnancies, causing concern among parents and community leaders (Gibbs et al., 2022; McKenna et al., 2020).

Methodology

The study employed a qualitative research approach, using in-depth semi-structured interviews to gather the views of the Sinisbai community in the Western Highlands Province on traditional culture and its associated changes. The study was conducted on March 17, 2022, as part of a group research project titled ‘Social perspectives of different age and gender groups in selected communities in Western Highlands, Jiwaka, and Madang Provinces, PNG’.

Although the broader project covered topics such as culture, youth, children, widows and orphans, social changes, and development, this paper specifically focused on modernization and cultural changes in the local community. The data used in this paper were derived from the researcher's individual interviews, as some of this information was not captured in the published group research findings. With support and permission from the team leader, the researcher utilized these additional data to write this paper.

The researcher conducted two focus group interviews and six one-on-one in-depth interviews. Prior to data collection, a written request was sent to the Headmaster of Sinisbai Primary School and the community leaders to obtain their permission to conduct the study. Upon receiving approval, participants were approached and invited to participate in the interviews. Only those who expressed interest and provided both written and verbal consent were interviewed.

The study employed purposive and snowball sampling techniques, both of which are widely used in qualitative research (Sekaran & Bougie, 2016). The researcher intentionally selected participants deemed most valuable in answering the research questions. The interview data were recorded on a mobile phone, later downloaded to the researcher's computer, and transcribed.

The interviews were conducted in Pidgin, and the transcription and analysis were also performed in Pidgin. Data were analyzed thematically through the following steps: First, during data preparation, audio recordings were downloaded to the researcher's computer and carefully transcribed. Second, preliminary observations were noted. Third, initial coding, a detailed examination of the data was conducted to identify codes and develop categories with similar meanings, leading to summarized insights. Fourth, coding scheme development, initial categories were refined into a coding scheme, ensuring consistent feedback from participants was captured. Fifth, dataset application, the coding scheme was applied across the entire dataset to ensure comprehensive analysis. Finally, thematic mapping, a thematic map was created to illustrate the relationships between codes and themes based on shared categories (Roulston, 2001; Boyatzis, 1998). This systematic approach provided a clear framework for understanding the community's perspectives on modernization and cultural change.

Table 1: Profile of participants

No	Participant	Pseudonym	Number of participants	Gender	Age
1	Focus Group	Focus Group#1	10 plus participants	Male	35-60
2	Focus Group	Focus Group#2	8 participants	Male	35-50
3	P1	Participant#1	1	Male	45-55
4	P2	Participant#2	1	Male	45-55
5	P3	Participant#3	1	Male	45-55
6	P4	Participant#4	1	Male	55-65
7	P5	Participant#5	1	Male	35-50
8	P6	Participant#6	1	Female	35-40

Table 2: Coding of themes

No	Initial themes	Findings Coding themes
1	Influence of modernization on culture and traditions	Influence of Christianity on tradition and culture
2	Marginalization and exclusion	Collective decision making
3	Intergenerational conflict	Respect leaders and elders

Findings and discussion

Influence of Christianity on tradition and culture

All participants from both focus groups and individual interviews confirmed that their traditional culture has changed significantly over the years, with some aspects gradually fading away. Major traditional practices that are no longer observed include "tribal fighting, moka ceremonies, traditional feasts, the use of poison to kill enemies, and traditional singsing or dances" (Participant #2). Participants highlighted that "Christianity and education" have had a profound influence on their community and personal lives (Participant #3). When asked about the impact of these changes, participants generally viewed them positively. One participant shared:

> "We have accepted Christianity and converted ceremonial grounds into church buildings to proclaim the word of God. The tradition of poisoning people, especially enemies, has ceased and is no longer practised. It was a custom of our grandfathers but has changed due to the influence of Christianity and education" (Focus Group #2).

Participants further emphasized that Christianity has brought peace to their community. They noted the presence of 34 different church denominations in the area, which have collectively formed a Peace Steering Committee. This committee made up of pastors from various denominations, raises awareness about social issues such as drug use, alcoholism, tribal fighting, and other related concerns.

Additionally, participants acknowledged the role of strong community leadership in maintaining peace. They reported that the seven ward councils in the area have enjoyed over 70 years of peace, with no tribal conflicts. They expressed deep appreciation for Fr. William Ross, a pioneer missionary to the Western Highlands Province, who introduced Christianity to the region. One participant stated:

> "We thank Fr. William Ross for bringing three important things to Sinisbai and the Western Highlands as a whole in 1934: The Catholic Church, health, and education. These three contributions have greatly helped our community, allowing us to live in peace" (Focus Group #2).

One of the participants further mentioned that an important cultural practice of the Sinsibai people, which is no longer observed today is the traditional pig-killing ceremony. This was shared by Participant 4: "Many of our traditional cultural practices have disappeared as our fathers passed away, taking these customs with them". For example, they used to raise many

pigs and held special pig-killing ceremonies during specific times, such as when the leaves turned green, and crops like greens grew well in the garden. For such ceremonies, they prepared stones for a mumu (an underground oven for roasting pigs), gathered dry firewood, and readied greens, kaukaus (sweet potatoes), and bananas. The pigs were then slaughtered, and a large feast was organized, bringing together family and friends from far and wide. To distribute the pork, a big wooden table was prepared, and the meat was shared among brothers, sisters, uncles, aunties, and others. Unfortunately, this custom is no longer practised. "As our fathers passed away, these traditions were lost with them" Participant 4. He further mentioned that during these ceremonies, extended family members would gather, making it an excellent opportunity to strengthen relationships. However, with the decline of such traditions, we have lost this valuable way of maintaining contact with our extended families.

The study findings revealed that most participants attributed the peace and order in their community to the diligent work of churches. Through their preaching of the word of God and consistent promotion of peace and justice, churches have played a pivotal role in fostering harmony. This observation aligns with the literature (Ketan, 2013). The Western Highlands Province (WHP) benefits from strong community leadership, with most issues being resolved internally by the communities themselves. In many villages, there is no police presence, as law enforcement is typically stationed only in district centres or Mt. Hagen town. The peaceful environment in these communities is largely attributed to the influence of churches and their continuous efforts to preach the word of God. However, the disadvantage is that some good cultures are no longer practised today such as the traditional pig-killing ceremony which unites all the extended family members when they get together for the event.

Collective decision making

From the two focus groups and six individual participants, all respondents provided consistent answers when asked about how decisions that affect the community are made. It was emphasized that decisions are not made by one individual but are the result of collective agreement within the community. Participants explained that any matter involving the community, such as projects like building a school classroom or a church, is widely discussed, and decisions are made collectively rather than by village leaders or councillors alone. One participant stated:

> "As a leader and councillor of the people, it's hard for me to make decisions on my own. Yes, I am a councillor, but people in the community have different views and opinions. Hence, I gather input from the community to make a collective decision. It's not a one-man decision but a collective one" (Participant #1).

Participants further explained that while individuals may independently make decisions regarding their families, community-wide decisions involve input from everyone. They highlighted that the decision-making process is inclusive, ensuring that no one is excluded. This process takes time—often weeks or even months—to reach a decision that benefits the entire community. A focus group member noted:

> "We all discuss and come up with one decision because it's not something for one person to decide. It's a community matter, so we all contribute to the discussion and

agree on a decision" (Focus Group #2).

Additionally, participants stressed the importance of effective communication in the community. Leaders continuously share messages encouraging positive behaviour, such as attending church, working in the garden, and avoiding alcohol consumption, drug use, and prostitution (Participant #4). They also mentioned that raising awareness is an ongoing activity aimed at fostering good habits and preventing social issues.

Respect leaders and elders

The majority of participants expressed that youths in the village generally show respect for their leaders, elders, and parents. However, a small minority tend to disobey their leaders. One individual interview participant shared the following when asked about the relationship between older and younger generations:

> "As leaders, when we talk to them (young people), they usually cooperate with us. Maybe 90% of the young people listen to the leaders, but about 10% misbehave and do not cooperate" (Participant #1).

Additionally, most participants, both in the focus groups and individual interviews, discussed disciplining children as a way to guide them toward becoming responsible and productive members of the community. They stated that when children are caught engaging in misconduct, such as stealing, fighting, or committing other crimes, they are disciplined by being beaten. Participants emphasized that this is considered a form of discipline, not child abuse. In the village, if an adult is found abusing a child without a valid reason, they are held accountable and may be required to pay compensation. However, one participant shared a differing perspective, informed by the training received from the Catholic Church. This individual advocated for non-violent approaches to discipline, such as talking to children and encouraging them to attend church. As one focus group participant noted:

> "Some of us attended training provided by the Catholic Church, where we were taught that beating children is not the right way to discipline them. The proper way is to talk to them and correct their behaviour" (Focus Group #2).

Conclusion

The study aimed to identify cultural changes in the community that can be viewed as both positive and negative. The study found that there have been changes in the traditional culture of the people of Sinsibai in the Western Highlands Province. While the local people have preserved some positive cultural practices, they have also let go of those that are not beneficial to the community. For example, due to the influence of Christianity and education, tribal fighting no longer occurs in the village. The community has enjoyed over 70 years of peace, which has allowed people to engage in business, education, and agriculture. Most importantly, Sinsibai has strong community leadership, with most issues being resolved by community leaders rather than the police. However, one interesting cultural practice that is dying out is the traditional pig-killing ceremony. This is no longer practised, as young people are not rearing pigs, and organizing such a ceremony requires considerable time and effort. This ceremony was used to bring extended families together. Despite these positive changes,

challenges remain, such as the consumption of marijuana and alcohol by a few individuals in the community.

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Health service delivery in the Middle Ramu District of Madang Province in Papua New Guinea

Joe Russell Agavi

Abstract

Developing countries face many challenges to service delivery, despite efforts being made by governments and relevant organisations. Developing countries have many in common when faced with health service delivery. Commonalities exist in the challenges and solutions they bring to mitigate the impacts of the lack of service delivery. Papua New Guinea (PNG) like other countries faces similar challenges. The basic health needs of the vast rural-based population remain unsatisfied. The Middle Ramu, one of the districts, has been identified as one of the least developed in PNG, with poor health service delivery. This paper reports on a study undertaken to identify some challenges to health service delivery and provide recommendations to address these challenges. Mixed methods were employed, including questionnaires and interviews to collect data, which were then analysed using statistical and thematic analysis. The findings identified various challenges and recommendations for improvement. The Madang Provincial Government and Health Authority can use these findings and recommendations to make proper planning and decisions so that the status of service delivery is improved to the expected levels.

Keywords: Health service delivery, Madang Province, Middle Ramu District, Papua New Guinea.

Introduction

Madang Province has one of the most underperforming health systems in PNG despite several initiatives undertaken for improvements in the past decade (Prideaux, 2014). Ineffective leadership, management competencies and weak political and institutional capacity are barriers to effective health service delivery. Further, accessibility to health facilities is a critical factor in effective treatment for people in rural areas in developing countries (Murawski & Church, 2009). Health services delivery to a certain population in such areas is a challenging task. It is usually straining when one is expected to deliver to a remote, isolated and less developed district.

This paper will report on a study undertaken to explore the factors affecting health service delivery in the Middle Ramu district and provide recommendations so that the MaPHA, Middle Ramu District Development Authority and relevant stakeholders can collaborate to improve health services delivery mechanism to serve the people better in Madang Province.

Research context

Health services in PNG have been categorised into rural and urban health services. The recent restructuring of the National Department of Health's focus on health service delivery led to the introduction of the Provincial Health Authority (PHA) (PNG Government, 2007). This concept was first introduced in 2007 when it was proposed that these two categories be

amalgamated into one coordinating authority. It was believed that with the decentralisation of the health functions to the provincial level, outreach to the local districts would be manageable and implementable. However, the implementation process and the work of the PHA have not been working effectively as envisioned in some districts such as Middle Ramu in the Madang Province. Joe Agavi is a board member of the Madang PHA and is interested in such studies. Thus, the findings and recommendations of this study will be submitted to MaPHA to be used for proper planning and implementation of health services in Madang and other provinces as appropriate.

Literature Review

Health service delivery in developing countries

Developing countries face many challenges to service delivery (Macintyre, 2019). Despite efforts by governments and relevant organisations, the basic health needs of the vast rural-based population remain unsatisfied (Djukanovic & Mach, 1975). Some challenges include unpleasant and difficult terrains and land formation, lack of political direction, corruption in government delivery systems and lack of attention to basic service delivery by those responsible. PNG is not immune to such challenges (Murawski & Church, 2009). Despite many attempts to introduce various intervention programs to alleviate and improve this sector of developmental expectations, some rural areas are slowly seeing improvements whilst some are struggling to see results.

The challenges to delivering goods and services are a great agenda that is driving governments and leadership across the globe in their endeavour to provide for their people. Governments have initiated various reforms to effectively deliver to the majority of the population (Lindquist, 2011). These challenges become far greater and more stressful when faced with economies or environments that are underdeveloped with an unbalanced act of developed economies on one end of the scale and the least developed on the other extreme (Mohammed, 2016).

Health service delivery in Africa, Asia and the Pacific

Developing countries in Africa, Asia and the Pacific have many in common when faced with health service delivery. Commonalities exist in the challenges and solutions they bring to mitigate the impacts of the lack of service delivery (Peters, et al., 2008). These challenges include the issue of leadership and its accountability in terms of decision-making and the distribution of resources to all areas under its mandated coverage. Maxwell's famous quote often iterated in discussions and literature, 'everything rises and falls on Leadership', rings true of the failures or successes in capably and effectively providing for the people they are mandated to serve (Maxwell, 2024). Another common factor hindering health service delivery is the natural environment including its geography, weather, and seasonal changes that accompany those, which create accessibility and logistical issues (Peters, et al., 2008).

There is also the rural-urban drift that is placing a burden on the service delivery mechanism. It poses some challenges in the rural as well as in the urban areas even though there are expected benefits (Moses et al., 2017). In most rural areas, the drift led to rapid deterioration

and dysfunction of the rural economy leading to chronic poverty, a drop in enforcement of law and order and food insecurity. It is not only affecting rural areas but also pushing the implementers of public policy and service delivery to urban areas. The public servants abandon their work locations in search of comfort and pleasantry in urban and suburban areas (Gibbs, et al., 2016). Changes can occur if leadership focuses on time, budget, visibility, ownership, personal contact and relationship-building with its people (Peters, et al., 2008).

Many rural areas have vast and diverse geographical locations, which prohibit proper penetration of health care (Panagariya, 2014). Healthcare personnel are reluctant to work in such areas as they have to face challenges such as the absence of reasonable living conditions (e.g. proper housing, electricity and a good school for their children) and the under-functioning of the majority of healthcare facilities in such areas, which provide limited opportunity to apply their knowledge and skills.

Health service delivery system in PNG

PNG's health services have been decentralised with leadership and management roles, finance and service delivery to provincial and district governments (Prideaux, 2014). The provincial hospital had its governance structure, whilst the districts operated under the rural health sector. The two separate governance systems led to continuous challenges and conflicts in the delivery of quality health care to the needy at an affordable cost (Littlejohns et al., 2012). In recognising this weakness, the PNG government enacted the Provincial Health Authority Act 2007, to establish provincial health authorities so that the two separate governance structures can be amalgamated into one system. Madang Province obtained its PHA status in 2019 (TVWAN, 2024). The MaPHA is now charged with the responsibility of managing all health facilities and services in the province.

Health service delivery in Madang

The Middle Ramu district has been identified as one of the least developed in PNG (Gibbs, et al., 2016). Currently, there are about fifty aid posts in the district. Twenty-three are in operation whilst twenty-seven are closed for various need-to-be-explained reasons. The district has seen little changes and is one of the most disadvantaged districts (Rogers et al., 2011). Many factors that hamper service delivery include road and transport infrastructure barriers, law and order, pay structure, drug and medicinal procurement and supply and the responsiveness of the local and administrative leadership (Prideaux, 2014). The district has also faced other challenges such as floods and scattered terrains and rivers in the delivery of health programs, resulting in poor access to outside markets and services. These issues were further explored in this study.

Methodology

Methodology refers to "how research should be undertaken, including the theoretical and philosophical assumptions upon which research is based and the implications of these for the method or methods adopted" (Saunders et al., 2016, p. 720). It includes the methods used to collect and analyse the data collected to answer the research questions. Mixed methods were

used in this study, that is, both the qualitative and quantitative methods of data collection and analysis, which were conducted concurrently.

Non-probability sampling was used as the Middle Ramu district is geographically dispersed, making it difficult to visit the whole area. Purposive sampling was used to identify participants for the interviews and convenience sampling participants for the questionnaires from four LLGs: Aiome, Josephtaal, Kovon and Simbai. These participants were believed to have the relevant data required to achieve the aim of the research.

Questionnaires were used to collect quantitative data and semi-structured interviews qualitative data. A semi-structured interview is a meeting in which the interviewer does not strictly follow a formalised list of questions (Saunders et al., 2016). Instead, they ask open-ended questions, allowing for a discussion with the interviewee.

The data collected from the questionnaires were entered into Excel and analysed using statistical techniques such as exploratory data analysis and descriptive statistics. The interview data were entered in QDA and thematically analysed. These data were analysed to identify the main challenges and provide recommendations for improvement in health service delivery. Ethical processes were followed, which included obtaining clearance and informed consent from the participants and keeping data confidential.

Findings

From the data analysis, there was a general consensus that health service delivery in the Middle Ramu district is affected by several factors including a lack of health workers, medicines and drugs, leadership and maintenance of existing infrastructure (Figure 1).

Figure 1: Challenges to health service delivery in the Middle Ramu District

Lack of health workers

The findings show that there is a lack of health workers. Many aid posts do not have health workers. They are either out in town sourcing drugs and medicines or have absconded from

work, and migrated to town or their villages, whilst on full pay by the National Department of Health (NDoH). A female villager (54 years old) from Arabaka stated, "ol lain save wok o raun nating nating, ol kisim pei nating (These health workers are not working, they are getting paid for doing very little or nothing)" (FPA1). A male ward councillor (48 years old) from Kovon, complained bitterly, "aid posts are like ghost houses, no workmen, no medicines" (MPK2). Another participant, a student from Kovon (28 years old) expressed in frustration, "we have not seen our CHW for a long time, he may be dead and buried in Madang town" (MPK3). There is a lack of health workers at all aid posts in the district (Figure 2).

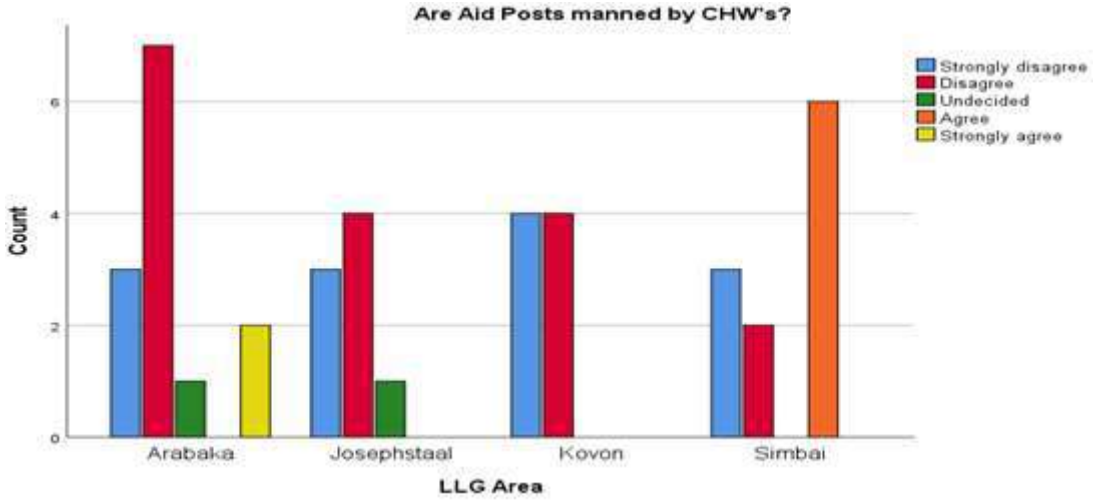

Figure 2: Manning level of CHWs at local aid posts

Lack of availability of drugs at health centres

Due to environmental constraints, road inaccessibility, and closure of rural airstrips, drug and medicine distribution to health facilities in the district has been very slow (Figure 3). The route taken to distribute medicines and drugs is by road, then by a river and then by foot to the respective health posts. For the Simbai health facilities, drugs are driven to Mt Hagen from Madang town, then airlifted to Simbai airstrip. This route is taken because the freight costs from Mt Hagen to Simbai are cheaper than from Madang to Simbai. The survey findings show that at most facilities, drugs are either very scarce or empty on the dispensary shelves.

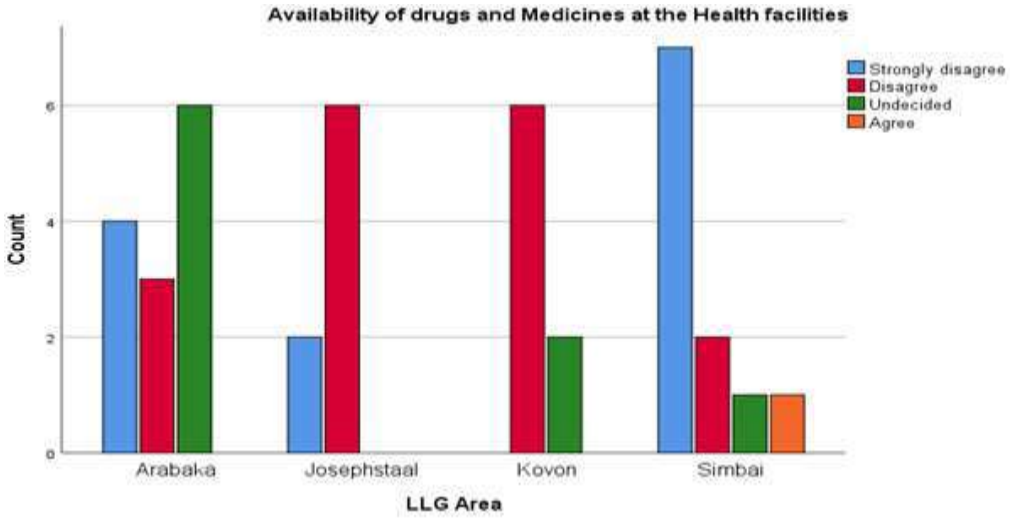

Figure 3: Availability of drugs and medicines at health posts

A case in point was recorded where drugs procured for Aiome in February 2021, were finally delivered on the 27th of July; a delay of 5 months after their procurement. At the Aiome health centre, it was found out that the local dispensary was depleted of much-needed drugs for over 5 months before replenishments arrived. A male Health worker from Kovon (aged 37), could not hold his emotions and said with tears, "I have lost so many mothers here due to lack of drugs; preventable diseases have taken hold and are killing people. There should be a better way to procure and transport drugs to us regularly" (MPK4).

Lack of leadership visibility

There is no presence or visibility of leadership in the district, which includes leadership at the local administrative, provincial and national government levels. A male participant (57 years old) from Kovon frustratingly stated, "Our district's leadership is dead. There is no one to see for help in our main district station of Aiome. They have all migrated to Madang" (MPK5). Another, a female participant (53 years old) from Arabaka stated, "we will not take part in elections anymore. We waste our time to vote for leaders when in reality there is no presence of both local and national political representation in the district" (FPA10). Another male participant (aged 47) from Arabaka stated, "all of the leaders have migrated away from the district and are now living and working or absconding from work and living in Madang town, Walium, and Ramu Sugar. The local Middle Ramu MP has offices in Madang town and Port Moresby. His local office at Aiome is unmanned and left in ruins" (MPA2).

The Middle Ramu District Development Authority (MRDDA) public servants have deserted Aiome District Centre and are now working out of a rented unit at the Madang Provincial administration centre.

The findings are similar to the literature, which indicates that leadership forms the core of the beginning of restoration or changes to be kick-started in the district. With good and visible leadership in the district, all other variables, such as roads and airstrips, law and order, and community support will fall into place to set a mechanism for change to start.

Lack of visibility of health workers

Many participants expressed having seen no visibility of health workers in the district for a long time (Figure 4). These include doctors, nurses, health extension officers and other general programs such as health and nutrition, maternal and child health, HIV Aids, TB, and related programs. A male participant (aged 48, a ward councillor from Arabaka) stated that "the last time we saw a full medical team visit Aiome was in 1992. Till now 2021, there was nothing of this sort of group visits" (MPA4). Another female participant (aged 42) from Josephstaal, stated angrily, that "our District Health Manager is hardly here, he comes in for a week and goes back and stays in Madang for months and months" (FPJ11).

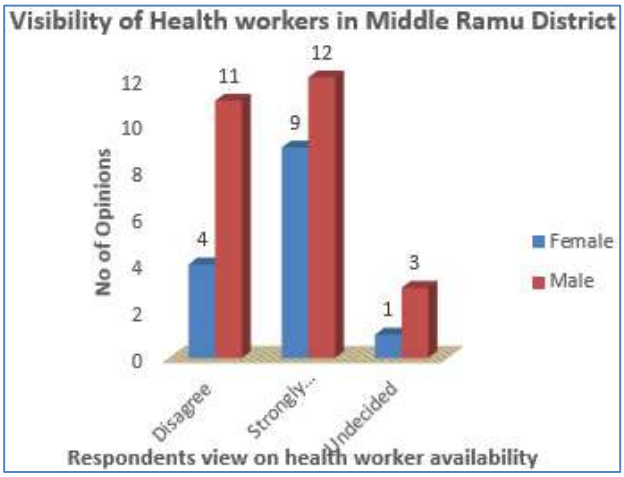

Figure 4: Visibility of Health Workers in the District

According to participants, rural-urban drift has impacted the level of service that is rendered at the rural district levels. Nursing officers, aid post orderlies, now termed CHWs, rural doctors, health extension officers, and health inspectors began the exodus from rural to urban settings. This is all done in the name of seeking the urban pleasantries of good education, entertainment, cheaper and affordable costs of goods and services, affordable and reliable running water and sanitation systems and a general upgrade in the standard of living for their families. MPS8 continued, "Ol yangpela i laikim hamamas blong taun na ol i go" (The young generation is attracted to the pleasantries of urban life and has left).

Aging workforce

Another factor that is contributing to the low level of health service delivery is the age of the present workforce. Most of the present CHWs and health professionals are nearing the retirement age of 60 or have gone past it. There is a far greater need for these officers to be retrenched and for new fresh and young CHWs to fill in the positions. A male health worker (aged 60) from Simbai stated, "I will work till I drop dead. There is no young health worker that wants to come to my aid post as it is not attractive to work here" (MPS5).

Drop in Communications and information reporting

Reporting issues from the district level to the provincial level is also very ineffective. The research found that some areas do not have adequate mobile phone coverage. However, they stated that the 2-way radio communications as practiced in the past were effective in that messages were sent and received extensively.

Road and airstrip improvements lead to better service delivery

Many participants agreed that the key to the successful improvement of health service delivery in the Middle Ramu district lies in the need to upgrade roads and airstrips (Figure 5). Due to the district's massive scattering environment, roads and airstrips will open up the way for improvement.

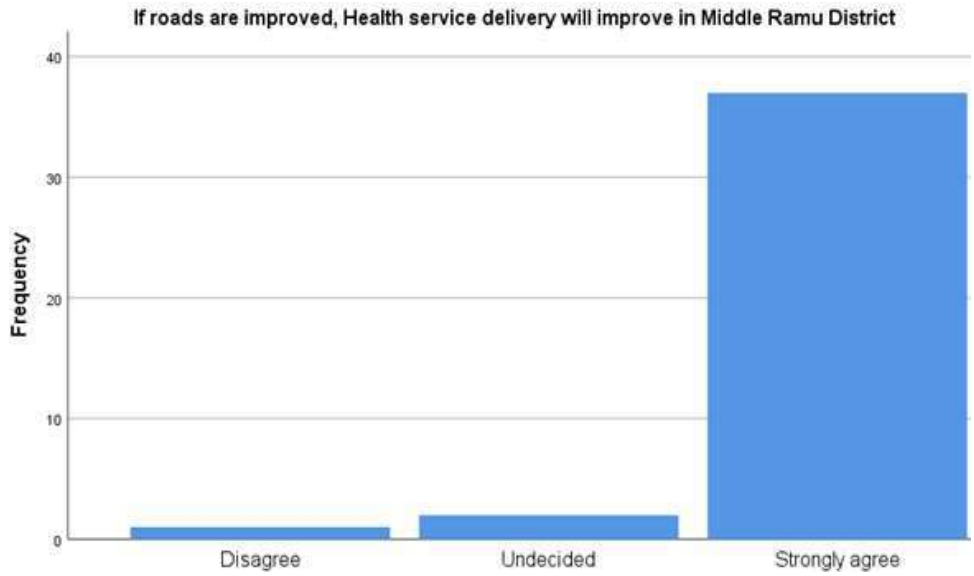

Figure 5: Impact of road and airstrip improvements on health service delivery in Middle Ramu

A male participant (retired public servant aged 56) from Arabaka proclaimed with vigour that "roads and airstrips are the keys to resurrecting this district. Leadership at all levels should work together to drive this infrastructure agenda if Middle Ramu is to see real and meaningful change" (MPA5). There are pilot tracks that need an upgrade and permanent gravelling, which will enable easier transport of goods and services. These pilot tracks are from (i) Sogeram to Umerum to Pasingkap and Atemble, (ii) Sogeram to Agraski and (iii) Zukin to Guam and Ramu River. The upgrades of these identified tracks will greatly aid the health sector with:

- mobilization and transportation of drugs, vaccines, and medicines,
- movement of medical officers for diagnosis, immunization, and public health programs,
- movement of awareness teams on nutrition, TB, HIV AIDS, nutrition,
- transfer and referral of patients, both critical and non-critical for further medical diagnosis,
- movement of medical officers seeking other services like schools for their children, banking, general shopping, and personal matters.

Factors of attraction in reducing urban-rural migration

The respondents, mainly health workers, suggested that (i) housing subsidy, (ii) allowances and attractive remuneration and (ii) fixtures and furniture, be provided to lure, motivate and retain health workers in the district.

Comparison of Health service delivery in different periods

Health services were delivered better in the periods between 1960 and 1980. The service delivery levels started to fall in the period after that from 1981 to the present. 57.5% of respondents agree that health services were delivered better in the years from 1960 to 1980. When the colonial government and white expatriate officers were administering the district, respect for the rule of law, cleanliness, housekeeping and the general good behaviour of people were in existence. The costs of goods and services were cheap and affordable at the time, including the costs of fuel and basic store goods. Schools and health centres were run by experienced colonial administrators, who managed rations, fuel supply, and people's attitudes well. A male participant (age 68) from Simbai stated that "everything was cheap. White man made sure all supplies are available for health and store goods. There were no law and order issues, everyone respected each other" (MPS8).

Poor state of service delivery

Service levels including roads in the rural Middle Ramu district are in a poor state (Kassa, 2024; PCAdminPNG, 2019b). After achieving political independence in 1975, PNGeans eventually took over the reins from white expatriates, which saw them leaving the rural areas for either the urban settings or immigrating to their homeland. The attention to detail in housekeeping began to fall, with district work cooperation amongst public servants fading away. Rivalry amongst public servants in particular roles caused infighting and conflicts, which led to a drop in service delivery levels.

Discussion

Contextual environmental /geographical spread

Middle Ramu District has four local level governments (PCAdminPNG, 2021). They are separated by the Bismarck mountain range and the meandering Ramu River and its many tributaries, making accessibility an arduous task. These physical barriers pose a great difficulty for effective health service delivery in the district.

Solutions in sight: Call for Leadership to step up

Some solutions have been discussed and agreed upon. All are now dependent and incumbent upon the political and administrative leadership at the district, provincial and national levels to make these changes happen (PCAdminPNG, 2019a). For the Middle Ramu District to improve its standings on the stakeholder performance grading, several prerequisites needed to be undertaken. Leadership is required to deal with road and airstrip improvement programs (PCAdminPNG, 2021). It then reverberates and transcends to answering the research question, which desires an improved and higher level of health service delivery, ultimately leading to a healthy population in the district.

Upgrade of existing road links

New roads new to be built and existing road links must be updated such as from Jimi Valley to Simbai (Kolo, 2024; Taime, 2023). There is also another pilot track that is left to see the overgrowth of bushes from Sogeram to Umerum. The road can be resurrected from Umerum to lead to Atemble, which can give easy access to Aiome, Kwanga, and Annaberg (Arabaka) and the Kovon LLGs, situated towards the border of Western Highlands and East Sepik Provinces. There is another existing road route from Bogia coastal to Josephstaal. There is only a 6-kilometre stretch that is yet to be cleared, upgraded, and made accessible for Josephstaal's use. The fourth road route, which should give access to the Kovon is from the Bogia coast to Igom, then to Zukin. This reaches the Ramu River and enables access to Kovon.

Existing machinery from the PNG Defence Force Engineering Battalion (PNGDFEB) is currently sitting idle at the Aiome District station for the last seven years (Figure 6). These machinery, plant, and equipment can be readily utilized by the district to grade the pilot tracks. It only needs funding for fuel, mobilisation and manpower, which can be met by the Middle Ramu District Development Authority (MRDDA).

Figure 6: Idle PNGDFEB machinery sitting in Aiome station for the last 7 years

Road and airstrip access can open up the way for (i) faster and easier delivery of medicines and drugs, (ii) faster mobilization and referral of sick inpatients and outpatients to the District Health centres and eventually to the main Madang Hospital, (iii) general nutritional, TB, HIV Aids, Coronavirus and maternal and child health programs can be easily provided by the health department officials, and (iv) for a specialist team of doctors and health officials to constantly visit the Middle Ramu on planned consultation visits, (v) The road and airstrip access will also enable public servants, especially health workers, who have deserted the district to live in Madang town (PCAdminPNG, 2019b) to return to the District station at Aiome, Simbai, and Josephstaal to return and provide the much-needed services, (vi) the Rural Airstrip Agency (RAA) can be engaged by the local national Member of Parliament to upgrade the number of airstrips in Middle Ramu. Recently the RAA was engaged by the South Bougainville MP to upgrade and open the unused Buin airstrip (PostCourierOnline, 2021).

This improvement in roads and airstrips can also lead to a resurgence of business activity, opening up opportunities for cocoa, vanilla, and beetle nut trade, which can sustain the Middle Ramu people's economic livelihood. It will also fulfil the national government of Papua New Guinea's Vision 2050, which calls for the population to be Healthy and Wealthy (PNG Government, 2009).

Budget

To boost the motivation levels of the health public service delivery mechanism, the annual budget appropriation for the Madang and Middle Ramu health sector should be increased (Ambang, 2019). Further, decentralization of funding disbursement will give easy access to procure services, drugs, and supplies at the local level, rather than the present cumbersome process, which is engrossed in red tape and delays. Appropriate funding is required to implement programs such as TB and HIV prevention, food nutrition and handling, quarantine inspection patrols, water supply and sanitation and the Healthy Island concept.

Enabling factors

To boost performance levels, several enabling factors needed to be considered and procured to greatly assist the endeavour. These factors include equipment and assets such as vehicles and dinghies that will enable the mobility of health officers to visit all facilities to carry out the relevant programs and improve service delivery (Ambang, 2019).

Sponsorship, training and motivation

Since Madang has several health training institutions such as the Divine Word University, Lutheran School of Nursing and Gaubin CHW training school, the Madang PHA in conjunction with the MRDDA should sponsor capable students from the 4 LLG areas to undertake training on health-related areas such as nursing or health extension. The administration can then tie the graduate outputs to employment contracts to work at the 4 LLG areas, and provide mechanisms such as incentives to retain them in the district.

Recommendations

With all the enabling factors in place, the onus is now on the Madang Provincial Health Authority as well as the Middle Ramu District Development Authority to take full control and ownership of the health facilities and undertake the following regularly.

i. Conduct consistent audit visits to ensure accountability in reporting, drug administration, and adherence to manning requirements.
ii. Conduct planned in-service training for areas of need for health officers at their posts.
iii. Assist poor-performing facilities to improve in their key indicators.
iv. Transfer officers based on performance and need.
v. Assist with fuel for dinghies, vehicles, and motorcycles.
vi. Allocate sufficient budget for repair and maintenance of transport (road and river to ensure continuity of service delivery levels.
vii. carry out a planned and programmed maintenance of one health centre at the given period.

viii. Take over the responsibilities of the distribution of drugs, medicines, and vaccines to all health facilities from the current external contractor.
ix. Engage doctors, health extension officers, health inspectors, and nursing officers to work in the rural outposts.
x. Organise life skills training for young health professionals as part of the professional profile.
xi. Install integrated 2-way radio services to remote areas inaccessible by mobile phone connectivity. The survey found out that when these were installed by the former Health Minister – Sir. Peter Barter in 2007, they were working very effectively in disseminating awareness and service messages.

With the implementation of the suggested recommendations, the integrated and cooperative approach between the leadership of MaPHA, the Middle Ramu political leadership and the Middle Ramu District Development Authority and the enabling factors as presented, the current level of health service delivery in the Middle Ramu District can be improved in the next 3 to 5 years, further leading to an improvement in the district's national profile and health standard ranking.

Conclusion

This paper presented the results of the research, which was aimed at identifying the factors that contributed to the low level of health service delivery in the Middle Ramu District. The paper also offers suggestions for improvements and measures to be undertaken by the relevant authorities in the political, administrative and health sector leadership to embrace and implement to achieve positive changes and progress in the health service delivery mechanism. It is incumbent that these findings and the recommendations should be implemented by the relevant stakeholders, especially the district's leadership in their strategies and plans to enhance the health service delivery mechanism. This will contribute to a healthier population and a realisation of improvements in the district's annual national rankings, which have been placed in the lower rung of the 89 districts of PNG.

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Appendices

The following photos were taken during the data collection trip to the Middle Ramu District.

Loaded with 57 cartons of Drugs, vaccines and medicines for Aiome Health Centre

Posing in front of Aiome Health Centre with the OIC –Mr.David Wunding

The dilapidated labour ward at Aiome Health Centre

Bushes and overgrowth cover the Aiome airstrip

Two of the Middle Ramu district health services' workhorses

Electronic government: National Online Application System in Papua New Guinea

Martin Daniel

Abstract

Digital technologies are increasingly transforming e-government services worldwide, enhancing the efficiency and effectiveness of educational service delivery. In Papua New Guinea (PNG), the Department of Higher Education, Research, Science, and Technology, in collaboration with PCG Academia, has developed the National Online Application System (NOAS) to streamline the application process for grade twelve students seeking admission to higher education institutions. This paper examines the NOAS initiative, providing an overview of higher education in PNG, the challenges of the traditional application process and the transition to a digital system. It discusses the NOAS implementation, its integration with the National Online Selection System (NOSS), and its resulting benefits for students and institutions. The paper concludes with recommendations for improving the system and future development pathways.

Keywords: backup choices, Department of Higher Education, Research, Science and Technology, non-school leavers (NSLs), school leavers (SLs), grace period, higher education, Information and Communication Technology, manual application process, National Online Application System, National Online Selection System, PCG Academia.

Introduction

The transition from manual to digital processes in educational systems worldwide has significantly enhanced efficiency and accessibility. In Papua New Guinea (PNG), the introduction of the National Online Application System (NOAS) marked a pivotal shift in how applicants (Grade 12 school leavers (SLs) and non-school leavers (NSLs)) apply for tertiary education. This paper explores the various facets of the National Online Application System (NOAS), its integration with the National Online Selection System (NOSS), and its overall impact on higher education in PNG.

In collaboration with PCG Academia, the Department of Higher Education, Research, Science, and Technology (DHERST) developed an online platform to streamline the application process for applicants seeking admission to higher education institutions. This paper examines the National Online Application System (NOAS), developed through this partnership. It provides an overview of higher education in PNG, the traditional manual application process, the challenges associated with the manual system, and the implementation and advantages of NOAS. Additionally, it examines the system's integration with the National Online Selection System (NOSS) and concludes with recommendations for improvement and considerations for the future.

Higher education in Papua New Guinea

Higher education is an important sector for national development in PNG (DHERST, 2018c). Higher education in PNG has evolved over the years, facing various challenges, including limited access, logistical hurdles and inefficiencies in application and selection processes.

Traditionally, Grade 12 students aspiring to enter tertiary institutions had to navigate a cumbersome manual application system.

DHERST

DHERST is the government agency responsible for overseeing higher and technical education in PNG (DHERST, 2015b). Its mandate includes policy development, institutional accreditation and the facilitation of tertiary education applications and selections. It collaborates with various government agencies and partners to promote skills, knowledge and innovation for sustainable development. Its vision is to drive economic and social growth through education, while its mission is to enhance the quality, access and relevance of education and research through effective policies and support systems. The introduction of NOAS is part of DHERST's broader strategy to modernise and streamline educational processes and improve service delivery.

DHERST's strategic plan focuses on transforming, reforming and unifying the higher education system to improve the quality of education (DHERST, 2015a). It aims to benefit PNG's social and economic development by enhancing programs offered by higher educational institutions. The plan also seeks to maximise student entry into universities and colleges and ensure their success by implementing strategies that help students achieve their educational goals.

DHERST's responsibilities include facilitating the SLs' applications for admission to higher education institutions (HEIs), aiming to enhance the process to ensure quality and equality in application choices (DHERST, 2024b). It also strives to improve transparency and accountability and increase the chances of capable and eligible students being admitted, while preserving the autonomy of institutions in their selection process (Papua New Guinea Today, 2017). To address challenges in the manual application process, DHERST launched an initiative in 2018 to develop an online system to streamline and improve the application process (DHERST, 2018b).

Manual application process

Before the introduction of NOAS, SLs had to complete paper application forms by hand, which were then physically submitted to DHERST (PNG Insight, 2023). The process of applying to programs at their preferred HEIs was entirely manual (Figure 1). DHERST distributed printed school leaver forms (SLFs) to national high schools, secondary schools and others offering secondary education, where guidance officers discussed academic performance, program preferences and eligibility with students. Students filled out the forms using their internal results and returned them to the school, which forwarded them to DHERST. Selectors from various HEIs then travelled to Port Moresby to choose their first-year students based on the student's choices and academic performance (Daniel, 2020). The selection lists were published in daily newspapers such as The National and Post Courier.

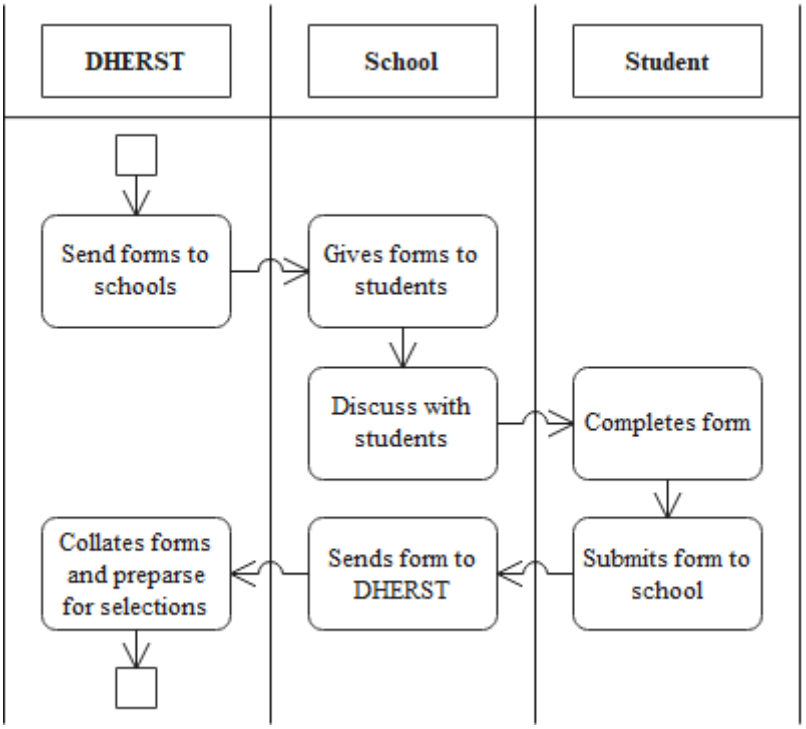

Figure 1: A model that shows how the paper-based application process works based on a student's internal results and preferred institutions.

Issues with manual application process

The manual process faced various issues including limited choices (Figure 2).

Figure 2: Issues with the paper-based application process

Students had limited options when filling out paper forms, which resulted in poor alignment between their choices and the programs offered by HEIs, leading to a low likelihood of selection for SLs (Daniel, 2020). Further, many SLs often underestimated or overestimated their academic potential and applied for programs for which they did not meet the academic requirements, ultimately missing out on opportunities in less selective programs. Some candidates with high GPAs opted for easier programs, while the manual selection process often overlooked more qualified candidates (DHERST, 2018c). Moreover, SLs had limited time to discuss their options with parents and guidance officers before submitting their forms to DHERST. They could not make changes after the forms were submitted.

SLs completed the forms before the national examinations, which prevented them from adjusting their choices afterwards. This situation resulted in misjudgements regarding their academic potential and incorrect program selections, highlighting the need for a national online application system. There were also delays in submission and processing, the risk of applications being lost or misplaced, a lack of real-time updates and feedback for SLs, and unequal access for students in non-urban areas. It was also costly and resource-intensive, as it involved printing and compiling a significant amount of paperwork. The forms were then mailed to schools nationwide.

National Online Application System

In December 2018, DHERST introduced the NOAS, developed by PCG Academia, which has extensive experience in developing information systems for student admissions and management across various institutions globally (DHERST, 2018c; Post Courier, 2017a, 2017b). DHERST engaged PCG Academia to develop the system to enhance the application process for SLs seeking to study at HEIs. This system allows SLs to apply online to attend a nationally registered HEI and specify their program preferences at their chosen institutions (DHERST, 2018a; DHERST, 2024b). “This is a new and better method to apply for further studies at any nationally registered university of higher education institution” (DHERST, 2018a, para 1). NOAS has replaced the traditional paper school leaver forms (DHERST, 2021; The National, 2020).

NOAS streamlines the application process for SLs seeking admission to higher education institutions (HEIs), enhances efficiency, and promotes equality and equity throughout the application and selection processes (DHERST, 2021). It addresses and mitigates the challenges faced by misinformed applicants and reduces instances of unfair selection. Since 2018, more than 27,000 students have submitted their applications using the NOAS.

NOAS on Google Cloud Platform

DHERST maintains an account with Google on its cloud platform to host its online services, which include NOSS and NOAS (Figure 3) (DHERST, 2021). Google Cloud Platform (GCP) is a set of cloud computing services that allow users to build, deploy and scale applications, websites and services using the same Google infrastructure (Google, n.d; Knox, 2024).

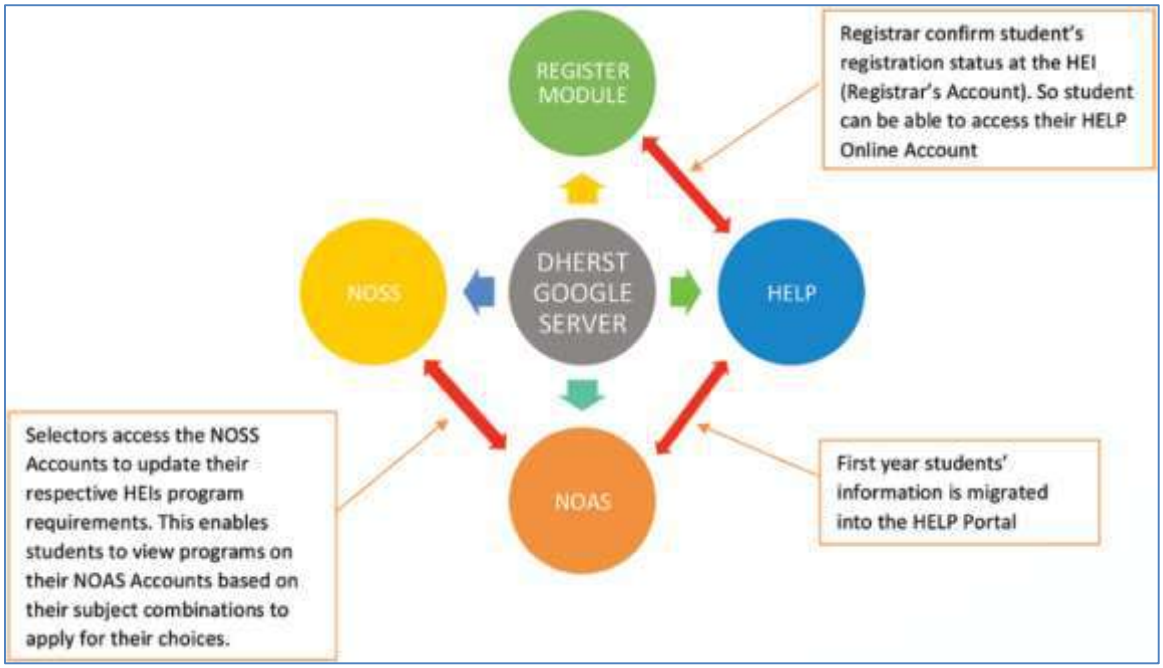

Figure 3: NOSS and NOAS servers on Google Cloud Platform
Source: https://web.dherst.gov.pg/images/2021-pubs/150621-ministerial-press-statement.pdf

DHERST operates two servers (application and database) hosted on the GCP (DHERST, 2021). One server runs the database software that stores NOSS/NOAS data, while the other hosts the web server for the NOSS and NOAS applications. Selectors use the NOSS to update their respective program requirements, allowing students to view programs on their NOAS accounts based on their subject combinations when applying for their preferred choices. DHERST then utilizes the NOSS to facilitate online selections (Daniel, 2022).

Integration with the National Online Selection System

NOAS is seamlessly integrated with the NOSS. This ensures that applications are processed and selections are made efficiently. NOSS uses a standardized algorithm to select applicants based on academic performance, subject combinations, choices and available spaces in tertiary institutions (Daniel, 2020).

SLs submit their choices through the NOAS. In 2024, NSLs were requested to apply through the NOAS but there were issues as will be discussed. Their academic results are provided by the Department of Education (DoE) to DHERST (PNG Insight, 2024b; Study in PNG, 2019b) (Figure 4). The NOSS utilizes this information to conduct the selection process electronically and generate a list of students chosen for programs at their preferred institutions (Daniel, 2020). Applicants (SLs and NSLs) can view their selection results online (indicating whether they have been selected) through the NOAS, which retrieves the results from the NOSS (Study in PNG, 2019b).

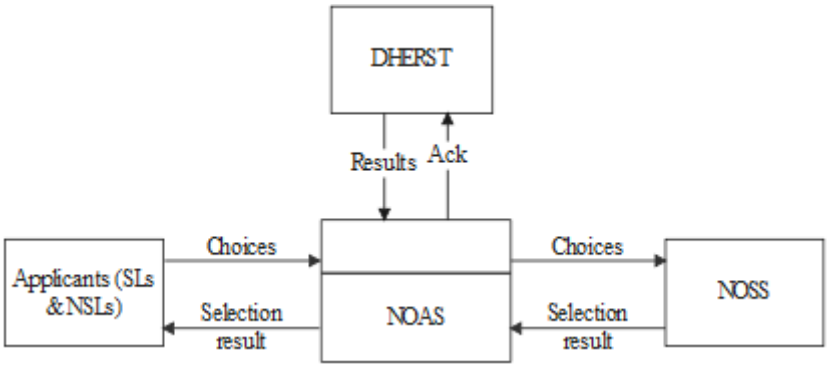

Figure 4: Integration of NOAS and NOSS. Applicants (SLs & NSLs) indicate their choices and view their results using NOAS after NOSS makes the selection.

NOAS features

NOAS provides features that aim to address the issues with the manual application process (Figure 5).

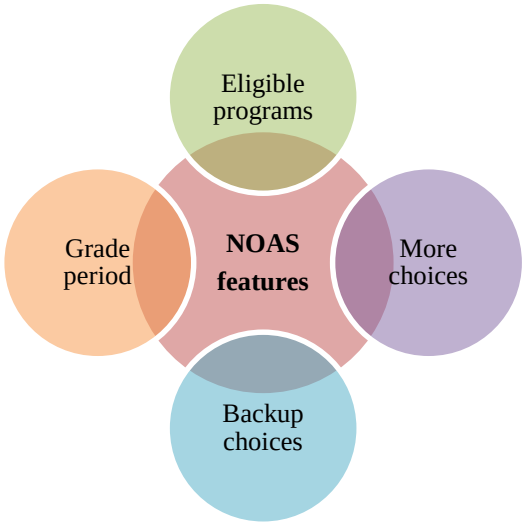

Figure 5: Some of the features of NOAS

- Eligible programmes - NOAS provides a list of programs for which applicants meet the eligibility requirements (PNG Insight, 2024a). When selecting their options, applicants can choose from this list to increase their chances of being selected.
- Increased choices - Applicants now have more options, as they can choose up to five programs at their preferred institutions (DHERST, 2018a). In contrast, the previous paper-based application process allowed SLs to choose only two programs (Daniel, 2020) while NSLs applied directly to the HEIs.
- Backup choices - In addition to selecting their top five choices, NOAS allows applications to indicate backup options. This feature enables them to be considered for alternative study programs if they are not selected for any of their initial five choices (Post Courier, 2018; Study in PNG, 2019b) These backup choices can either be similar to or different from their preferred programs, as long as the applicants meet the requirements (Daniel, 2020).
- Grace period - Applicants are usually provided a grace period of up to six days to access NOAS and finalise their program choices before the online selection is

executed (Post Courier, 2018; Study in PNG, 2019a; PNG Insight, 2024a). By this stage, SLs would already know their results, which are accessible through the National Online Results System (NORS) (https://www.mypngexamresults.com/). During the grace period, applicants have sufficient time to make informed decisions and finalize their choices (Daniel, 2020). After the grace period, the selection is conducted via the NOSS, and applicants can immediately see whether they have been selected, through the NOAS. In 2024, the grace period and online selection took place from 9 – 14 and 18 December 2024, respectively (DHERST, 2024d).

NOAS requirements

SLs need the following to apply for admission using NOAS.

- An invitation letter – This is created based on the nomination list, which includes Grade 12 students from all registered schools. This letter is provided to each student by the school principal or a designated senior teacher. Both the school and the SLs are responsible for maintaining the confidentiality of the invitation letters (DHERST, 2024b).
- Laptop or Smart Device – SLs need access to a personal computer, laptop or a smart device like a tablet, Android phone or iPhone. If the school has a computer lab with Internet access, students can utilize the lab computers to complete their application (DHERST, 2024b).
- Internet Connection – The personal computer, laptop or smart device being used must be connected to the Internet. If the student is using the school's computer lab, they should confirm with the lab supervisor to ensure Internet connectivity. For students using their devices, they can purchase data from local network providers like Digicel, Bmobile or Vodafone (DHERST, 2024b).
- NOAS Timeline – The invitation letter includes the necessary credentials to activate their online accounts. After activating their accounts, the student manual will outline the NOAS timeline and cycle activities (DHERST, 2024b). This information is also provided on the DHERST website.
- Grade 12 Students - The NOAS Student cycle for a year usually begins in August. Students can access their accounts and indicate initial choices. For further assistance, students can reach out to the NOAS student support team via email at noassupport@dherst.gov.pg (DHERST, 2024b).

NOAS typically opens in August each year for school leavers to begin the application process (DHERST, 2024a). In 2024, the NOAS was available from August to September and then in December during the grace period. To align with the PNG Government's 'leave no child behind' policy, DHERST and HEIs have established a pathway for non-school leavers (NSLs) to apply through NOAS. In 2024, NSLs were requested to contact HDERST, have their NOAS accounts activated and apply for admission into the 2025 academic year (DHERST, 2024a; DHERST, 2024c). However, as previously mentioned, there were issues with the NSL selection.

While finalising their choices, if the applicants notice a choice highlighted in red, under 'My Choices', it indicates that their results do not meet the minimum program requirements established by the institution (PNG Insight, 2024a). They need to replace the red-highlighted choices with a different program that is available in their eligible program list. They are encouraged to ensure they change their choice to a program for which their results meet the minimum requirements. If a program is not visible on NOAS, it signifies that the applicants are ineligible for that program (The National, 2020).

NOAS advantages

NOAS, in collaboration with PGC Academia, was developed to address the issues of the manual application process (DHERST, 2021). It has brought several advantages to the higher education application process in PNG (DHERST, 2018a) (Figure 6) including enhanced accessibility for students across the country, increased efficiency in application processing and selection, reduced administrative burden on educational institutions and greater transparency and accountability in the selection process. It allows students to submit applications online, view their status and receive timely updates.

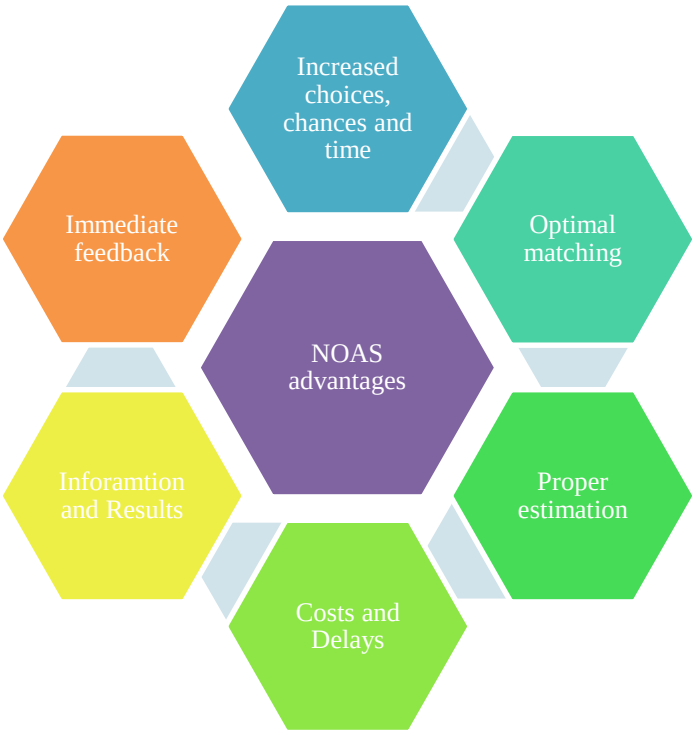

Figure 6: NOAS advantages

- Increased choices – Applicants now have more options, as they can select up to five programs at their preferred institutions (DHERST, 2018a). In contrast, the previous paper-based process allowed SLs to choose only two programs while NSLs applied directly to the HEIs as previously stated (Daniel, 2020).
- More information – Applicants now have access to more detailed information regarding the programs available at various institutions (DHERST, 2018a). Each program outlines specific requirements, preferences and residential options. Further,

NOAS displays the programs for which the applicants are eligible to apply, determined by their subject combinations and the criteria set by the institutions (DHERST, 2024a). If applicants cannot see certain programs they wish to apply for, it indicates that their subject combination does not meet the program requirements, resulting in the program not appearing (PNG Insight, 2024a). With this information, they can make more informed decisions about their choices.

- With the manual system, many SLs underestimated or overestimated their academic potential and applied for programs for which they did not meet the academic requirements. Some with high GPAs chose easier programs (DHERST, 2018c). NOAS allows applicants to make informed program choices based on their academic results and eligibility more realistically.
- More time – Applicants have more time to reach a decision, as the NOAS typically remains open for approximately three months (DHERST, 2018a). This duration allows applicants, parents and schools ample time to select the appropriate program and institution.
- Optimal matching - NOAS facilitates the alignment of program requirements with applicants' subject combinations, ensuring that applications correspond with the selected program's combinations. By matching subject combinations, the NOAS enhances the likelihood of admission by NOSS (Daniel, 2020).
- Increased chances - NOAS is transparent, efficient and cost-effective. As mentioned, it increases the chances of capable applicants being selected (Kora, 2017; Loop PNG, 2018) and ensures transparency, fairness and unbiasedness (Study in PNG, 2019b). For example, a principal in my province expressed that more students from his school were selected after the introduction of NOAS and NOSS (Daniel, personal communication, 2020), unlike in the past when applications and selections were done manually, which led to fewer choices, unfairness and nepotism (Daniel, 2020).
- Immediate feedback – Applicants can instantly find out whether they have been accepted into an institution (PCG Academia, 2017). Previously, they would wait for long periods to receive their offer letters, giving them limited time to raise school fees or secure sponsorship. With NOAS, they can view their status immediately after the online selection is conducted, giving them ample time to prepare for higher education (Post Courier, 2018).

Discussion and recommendations

NOAS brings a significant improvement in the higher education application process. It is a positive, practical, sustainable and timely initiative designed to address the issues related to the manual process. It streamlines the application process, ensuring a fair, efficient and cost-effective system. By replacing the manual process, NOAS has positively impacted academic operations, allowing capable applicants to be selected through the NOSS. It significantly reduces the logistical costs and time previously incurred by the manual selections, such as printing and distribution of forms.

NOAS has significantly increased transparency in the application process by addressing challenges associated with the manual process. It has done so by providing real-time monitoring and feedback, a standardised process for applicants, required information, guidelines and instructions, data security and integrity, reduced human intervention, visibility and equitable access to the program requirements and information.

DHERST must continue effective communication with all the institutions. This is essential to ensure that the HEI requirements in the NOSS are correct, accurate and current. These requirements must be communicated to schools, principals, guidance officers, applicants and their parents with clarity. Further, schools must supply relevant information regarding HEI program offerings and requirements to the students. They should offer adequate guidance to their students during the application process. Applicants can benefit from discussing their options with their parents, who can offer valuable advice in making their choices.

DHERST requires ongoing support from schools, applicants, principals, guidance officers, teachers, parents, HEIs, NDoE and other relevant stakeholders. Collaboration among these parties is essential to ensure that the NOAS is utilized effectively, promoting a fair and transparent application process that provides equal opportunities for suitable applicants.

Applicants must make informed decisions when choosing options through the NOAS. Timely access to their results is crucial for updating their choices or making any necessary adjustments to enhance their chances of being accepted into a program at their desired institution. Additionally, applicants should utilize the strategies mentioned earlier, such as backup choices and the grace period effectively.

DHERST should continue to provide awareness of how the NOAS operates, including its features and advantages through various media channels (like social media, television and newspapers). Necessary training may be required for schools, particularly students who may be unfamiliar with using the system. This awareness and training will help prevent misunderstandings and misconceptions.

In 2024, NSLs were required to apply through the NOAS after they had already submitted their applications to the institutions as usual. DHERST requested the institutions to submit their pre-selection lists and advise the pre-selected applicants to also apply via the NOAS. However, many NSLs did not apply as required due to various issues such as lack of communication with the NSLs. As a result, many pre-selected applicants were not selected by the NOSS. From 2025 onwards, DHERST must communicate early with the HEIs and NSLs and ensure that they apply using the NOAS so that they have equal chances of being selected. The above recommendations are necessary to ensure that this is implemented successfully.

Currently, the HEIs have limited capacity to increase their quota. The PNG Government must assist the HEIs to upgrade their facilities and increase their capacity to accommodate the increasing number of applicants applying for tertiary studies each year. Doing otherwise is

social injustice to the citizens, who deserve equal opportunities and better service delivery so that no one is left behind discriminately.

Finally, the PNG Government needs to address any challenges (e.g. limited internet access in non-urban areas and digital literacy among applicants), which require collaboration from DHERST, HEIs and the Government. The Government needs to expand the Internet infrastructure to ensure broader access, implement digital literacy programs for students and educators, establish a robust and reliable technical support system for NOAS users and conduct regular reviews and updates of the system based on user feedback. This brings out to the conclusion of the paper.

Conclusion

Digital technologies have allowed many countries to transform e-government services, improving their educational systems and providing educational services more effectively and efficiently. The PNG Government, through DHERST and in collaboration with PCG Academia, created the NOAS to enhance the educational process and facilitate online applications for applicants. NOAS has revolutionized the way applicants apply for higher education. While there are challenges to overcome, the benefits of NOAS in terms of efficiency, accessibility, security and transparency are undeniable. Continued efforts to improve the system will ensure its long-term success and contribution to the advancement of higher education.

This paper highlighted the significance of higher education in PNG, a crucial sector for the nation's socio-economic development. Delivering quality educational services can play a vital role in fulfilling some of the aspirations of the PNG Government. The paper examined the manual application process and its associated issues, such as limited options, reduced opportunities and time constraints, high costs and delays, suboptimal matching, loss and misplacement of documents, and a lack of timely feedback. It discussed the NOAS, how it works and integrates with NOSS and its advantages. Finally, it offered several recommendations aimed at enhancing the implementation and utilization of the NOAS. This initiative is viewed as a timely and beneficial advancement for the country, with the potential to significantly contribute to the nation’s socio-economic development.

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Contribution

This paper adds to the current body of knowledge by modelling technological developments in Papua New Guinea. Specifically, it documents the manual application process and its related challenges, as well as the NOAS, highlighting its features and benefits. Further, it illustrates how the NOAS resolves the issues associated with the manual process of facilitating applications for tertiary education. In this way, the paper serves as a valuable resource for future researchers in their studies.

Future paper

This paper is based on available literature about the national online application system. A future paper can discuss other aspects of the application processes not discussed in the paper.

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Factors that can affect academic staff in research and publication in Papua New Guinea universities

Kosley Wara

Abstract

Research and publication by academic staff are significant for several reasons: advancement of knowledge, academic excellence, teaching and learning enhancements, problem-solving, collaboration and networking, career development and recognition and new knowledge contribution to society. When an academic staff member does not actively engage in research and publication, several consequences arise: stagnation of knowledge, reduced teaching effectiveness, missed opportunity for professional growth, limited contribution to new knowledge in the discipline, decreased institutional reputation, limited collaboration and networking and reduced contribution to societal impact thus, research and publication are highly valued in academia. This paper discusses some of the factors that can affect research and publication by the staff at Papua New Guinea (PNG) universities. These factors need to be addressed for staff to engage in research and publication.

Keywords: factors, research, publication, academic staff, research productive, publication output, workload, business studies department, divine word university, Papua New Guinea.

Introduction

Research and publication are integral to the mission and success of universities. They advance knowledge, contribute to academic excellence, enhance teaching and learning, drive societal impact, support career development, foster collaboration and establish an academic legacy (Blackmore & Cousin, 2003). By prioritizing and supporting research and publication activities, universities can create an environment conducive to intellectual growth, innovation and positive change. Academic staff engaged in research and publication are integral to the success and impact of a university. Their involvement drives knowledge generation, enhances teaching and learning, fosters a research culture, elevates the institution's reputation, and makes a positive societal impact. Supporting and encouraging their research endeavours is vital for the overall excellence and advancement of the institution (Marsh & Hattie, 2002).

When staff are not engaged in research and publication, there can be limited contributions to knowledge, stagnant teaching practices, reduced collaboration opportunities, diminished institutional research profile, limited professional development, weaker industry connections, the potential impact on funding opportunities, and missed opportunities for student involvement (Iqbal & Mahmood, 2011). Universities need to create a supportive environment that encourages and facilitates research engagement among staff while also valuing and supporting their teaching and other institutional contributions.

This paper will discuss some of the main factors (from literature and experiences) that can affect research and publication at PNG universities. These factors need to be addressed for successful academic engagement in research and publication. These factors will now be discussed, starting with big student numbers in class.

Big student numbers

Lower student numbers in a class can provide academics with reduced teaching workloads, enhanced interaction and personalization, increased flexibility, and the freedom to align research with teaching. It can create collaborative research opportunities, facilitate resource allocation, foster interdisciplinary collaboration, and support professional development and recognition (Coleman, 1990; Heng et al., 2020). These factors collectively contribute to academics being more engaged in research and publication activities. Universities need to recognise the potential challenges associated with high student numbers and actively support academics in balancing their teaching responsibilities with research and publication. Allocating adequate resources, providing mentoring and support structures, and fostering a research-friendly environment can help mitigate the impact of high student numbers on academic research engagement (Dhillon et al., 2015).

High teaching workload

A low teaching workload provides academics with increased time availability, enhanced focus, and the opportunity to pursue complex research questions (Eam, 2015). It allows for longitudinal studies, facilitates collaboration and networking, supports professional development, enables the pursuit of external research funding, and contributes to recognition and advancement within academia. These factors collectively foster an environment conducive to engaging in research and publication activities (Iqbal et al, 2018). A high teaching workload can result in time constraints, reduced focus on research, increased administrative responsibilities, limited professional development opportunities, decreased motivation, restricted research collaboration, resource limitations and institutional emphasis on teaching evaluation (Eam, 2015). These factors collectively contribute to academics not being able to actively engage in research and publication activities. Universities need to find a balance between teaching and research expectations, provide adequate support and recognise the importance of scholarly activities in an academic's workload (Marsh & Hattie, 2002).

Writing skills

Writing skills positively contribute to staff engagement in research and publication by facilitating effective communication of ideas, producing high-quality research papers, enabling strong review and editing abilities, supporting successful grant and proposal writing, boosting confidence and motivation, facilitating effective collaboration and expanding publication opportunities (Lee & Boud, 2003). Staff members with strong writing skills are better equipped to actively contribute to research and publication activities, enhancing their impact and recognition within their academic field (Flowerdew, 1999). Poor writing skills can hinder academics' engagement in research and publication by affecting their ability to communicate effectively, write research papers, contribute to collaborative writing, review and edit work, find publication opportunities, maintain confidence and motivation, and write successful grant proposals (Flowerdew, 1999). Improving writing skills through training, practice and seeking feedback is crucial for academics to actively engage in research and publication, effectively communicate their ideas and increase their impact within the scholarly community.

Poor time management

Effective time management skills contribute to staff engagement in research and publication by prioritizing these activities, establishing clear goals and deadlines, creating a structured schedule, balancing responsibilities, minimizing distractions, efficient collaboration and networking, and regularly monitoring progress (Dundar & Lewis, 1998). By effectively managing their time, staff members can optimize their productivity, maintain momentum in their research projects, and actively contribute to the generation of new knowledge through publications (Bailey, 1999). Poor time management skills contribute to limited staff engagement in research and publication through a lack of prioritization, procrastination, over-commitment and overload, a lack of a structured schedule, difficulties in meeting deadlines, an inefficient workflow, and a lack of reflection and self-assessment (Dundar & Lewis, 1998). Addressing these time management challenges is crucial for staff members to effectively allocate time for research and publication, enhance their productivity, and increase their engagement in scholarly activities.

Plenty of work mindset

A positive mindset can significantly contribute to academics being engaged in research and publication, even in the face of heavy workloads. It enhances motivation, resilience, time management, problem-solving skills, collaboration, continuous learning, confidence, and work-life balance (Dundar & Lewis, 1998). Cultivating a positive mindset is beneficial for academics to maintain their enthusiasm, productivity, and commitment to research and publication, ultimately contributing to their professional growth and impact in their field. A ’plenty of work’ mindset among academic staff can negatively affect their engagement in research and publication by limiting dedicated time, reducing motivation, contributing to burnout and stress, diverting focus and attention, neglecting professional development, limiting collaborative opportunities, and reducing visibility and impact (Brew, 2003). Recognizing the importance of balancing workloads, prioritizing research and publication, and implementing effective time management strategies can help academic staff overcome these challenges and actively engage in scholarly pursuits (Eam, 2015).

Experienced academics

Recruiting experienced academics with a higher degree can lead to increased research and publication within a department by bringing research expertise, fostering collaborative research, providing mentorship and guidance, strengthening the publication record, contributing to research funding acquisition, expanding academic networks, nurturing a research culture and enhancing the department's reputation (Altback, 2011). Their presence can create a dynamic research environment and stimulate a culture of scholarly excellence within the department. Having academics with Bachelor's degrees and limited engagement in research and publication within a department can result in challenges related to limited research skills and experience, constrained academic networks, time constraints, lack of research incentives, limited access to research funding, limited career progression opportunities and a weak research culture (Chen et al, 2006). Overcoming these challenges requires institutional support, professional development opportunities, and recognition of the

importance of research and publication for academic advancement and the overall growth of the department.

Leadership

Effect leadership in an academic department contributes to staff engagement in research and publication by setting clear expectations, providing resources and support, offering mentorship and guidance, promoting collaboration and networking, recognizing and incentivizing achievements, facilitating professional development, creating a research-friendly environment, and leading by example (Healey, 2005). By creating a supportive and conducive environment, leaders empower staff to actively participate in research and publication, leading to increased scholarly productivity and the advancement of the department's reputation in the academic community (Bailey, 1999). Poor leadership in an academic department can contribute to limited staff engagement in research and publication by failing to establish clear expectations, provide sufficient resources and support, offer mentorship and guidance, foster collaboration and networking, recognise and incentivize achievements, prioritize professional development, create a positive work environment and promote role models (Eam, 2015). Addressing these leadership shortcomings is crucial for creating an environment that encourages staff members to actively participate in research and publication activities, leading to enhanced scholarly productivity and the advancement of the department's research profile.

Research and higher degree office

The Research and Higher Degree Office (RHDO) contributes to staff members' effective engagement in research and publication by providing research support services, facilitating access to funding opportunities, offering training and professional development, fostering collaboration and networking, ensuring research ethics and compliance, assisting with research communication and dissemination, supporting research impact evaluation, and establishing research policies and guidelines (Boud & Brew, 2012; Iqbal et al, 2018). By providing these essential services and resources, the RHDO creates an enabling environment that empowers staff members to actively participate in research and publication activities, leading to increased scholarly productivity and the advancement of the institution's research profile (Dundah & Lewis, 1998). An ineffective RHDO can contribute to limited staff engagement in research and publication through a lack of support and guidance, limited funding opportunities, inadequate training and professional development, limited collaboration and networking support, inefficient research ethics and compliance processes, a lack of research impact evaluation, and unclear research policies and guidelines (Dhillon et al, 2015). Addressing these shortcomings and improving the effectiveness of the RHDO is crucial for creating an environment that promotes staff engagement in research and publication, ultimately enhancing the scholarly productivity and reputation of the institution (Bailey, 1999).

Discussion

Factors that affect academics' engagement in research and publication within a department can have significant implications for the overall scholarly productivity and success of the

institution. Some of these factors include high student numbers, high teaching workload, poor writing skills, poor time management, a "plenty of work" mindset, lack of experienced academics, ineffective leadership, and ineffective research and higher degree offices. To address these factors, universities need to implement several strategies.

When it comes to student numbers, the university should consider implementing strategies to manage large class sizes, such as providing adequate resources, ensuring appropriate staff-student ratios, and offering support for innovative teaching methods that balance teaching and research demands. Similarly, teaching workload, institutions can establish workload allocation models that recognise the importance of research and publication, provide mentoring and support structures, and encourage a healthy work-life balance for academics. Writing skills, offering writing workshops, providing writing resources and support, and encouraging collaboration and feedback can help improve academics' writing skills and enhance their ability to contribute to research and publication. Moreover, with time management, universities can provide time management training, establish clear expectations and priorities, and support academics in managing their workload effectively. This includes promoting a culture of work-life balance and recognizing the value of dedicated time for research and publication.

On mindset, universities should foster a positive and supportive work environment that values research and publication, encourages innovation, and recognizes the importance of scholarly activities. This can be achieved through leadership support, professional development opportunities, and recognition of research achievements. Additionally, with experienced academics, attracting and retaining experienced academics with higher degrees can be facilitated through competitive recruitment processes, offering attractive research support packages, providing mentorship opportunities, and creating a collaborative and stimulating research culture. When it comes to leadership, effective leadership plays a crucial role in creating a research-supportive environment. Leaders should set clear expectations, provide resources and support, promote collaboration, recognise achievements, and create opportunities for professional development and advancement.

Finally, universities should ensure that the Research and Higher Degree office is equipped to provide comprehensive support, including research funding opportunities, training, ethical considerations, dissemination support, and policies and guidelines that facilitate research and publication. By addressing these factors and implementing supportive strategies, the university can create an environment that encourages and facilitates academics' engagement in research and publication. This, in turn, can enhance the scholarly productivity and reputation of the departments and contribute to the overall success and impact of the institution.

Conclusion

This paper highlighted several factors that affect academic staff's engagement in research and publication within a university department. These factors include big student numbers, high teaching workload, poor writing skills, poor time management, a "plenty of work" mindset,

lack of experienced academics, ineffective leadership, and ineffective research and higher degree office. To address these factors and promote research and publication activities among academic staff, universities should consider implementing various strategies.

These strategies include managing large class sizes through adequate resources and appropriate staff-student ratios, establishing workload allocation models that recognise the importance of research, providing support and mentorship structures, offering writing workshops and resources to improve writing skills, providing time management training and support, fostering a positive work environment that values research, promoting work-life balance, attracting and retaining experienced academics through competitive recruitment processes and research support packages, developing effective leadership that sets clear expectations and provides resources and recognition, and ensuring that the research and higher degree office offers comprehensive support services.

By implementing these strategies, universities can create a supportive environment that encourages and facilitates academic staff's engagement in research and publication. This, in turn, enhances scholarly productivity, elevates departments' reputation and contributes to the overall success and impact of the institution.

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Future Paper

This paper can be extended by including other factors and areas, which are not discussed here.

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Applications of IoT wearable device in healthcare: A consideration for healthcare services in Papua New Guinea

Rodney Gunik

Abstract

The interconnection of objects from the physical world comprised of sensors, actuators and connection to the Internet is called the Internet of Things (IoT). Driven by innovative ideas, these objects can be controlled and monitored remotely providing solutions to improve healthcare in terms of patient care, monitoring and management of patient health data while reducing the cost of healthcare. This paper aims to analyze the impact of IoT in healthcare. The paper further presents factors that motivate the use of IoT-WD in healthcare in developing countries. Finally, it discusses an architecture suitable for healthcare in Papua New Guinea.

Keywords: healthcare, Internet of Things, Unified Theory of Acceptance and Use of Technology, developing countries, LoRaWAN, systematic literature review, technology impact Analysis, Wearable device.

Introduction

The interconnection of objects from the physical world comprised of sensors, actuators and connection to the Internet is called the Internet of Things (IoT) (Dijkman et al., 2015). Driven by innovative ideas, these objects can be controlled and monitored remotely providing solutions to improve healthcare in terms of patient care, monitoring and management of patient health data while reducing the cost of healthcare. It has been considered to provide effective healthcare services to the elderly and patients with chronic diseases (YIN et al., 2016).

IoT's applications in healthcare range from managing chronic diseases to preventing them. The IoT wearable device (IoT-WD) can monitor blood pressure and heart rate but Gelogo et al. (2015) discussed specialized implanted IoT devices as well. There are emerging healthcare IoT platforms for antenatal and chronic patients to manage health necessities and recurring medical requirements.

This paper aims to investigate the applications of IoT-WD in healthcare by analyzing the impact of the technology. The paper will discuss the factors that motivate the use of IoT-WD in healthcare in developing countries. Finally, it will discuss an IoT-WD architecture suitable for healthcare services in Papua New Guinea (PNG).

Context of the study

The application of IoT-WD in healthcare has enabled patients to remain active when healthcare providers issue monitoring devices to allow them to continue their normal activities regardless of location (Lindén et al., 2016). Remote monitoring of a person's health status can enable early intervention and prevent conditions from developing further hence,

patients are prevented from suffering. This trend has now attracted the attention of the communication and health sector in recent years (Fotouhi et al., 2016).

A survey conducted in Europe from 2012 to 2013 shows that 9% of hospitals offer patients the possibility of using an internet-based application to monitor their health status (Maghiros, 2013). Two reports, "Mobile Usage in Medical Space 2013" and "Tablet Usage by Physician 2013" show similar results in the United States in 2012 where 39% of the surveyed doctors indicated the use of internet applications to communicate with patients (Granulo et al., 2016). In the Medium Term Development Plan III 2018-2022 (MTDP III) for the PNG Government, Key Result Area 3 describes the status of the traditional healthcare services and infrastructure in PNG which have deteriorated over the years due to priorities on curative rather than preventive healthcare (PNG Government, 2018). A clear example is the immunization coverage which is less than 40% compared to the global average of 80% not to mention the COVID-19 vaccination coverage in PNG.

Delivering an efficient, quality and improved healthcare service is a challenge for PNG (PNG Government, 2018). From the present literature, IoT-WD can improve quality and reduce the cost of healthcare services.

The IoT architecture

The IoT architecture is composed of a microcontroller unit (MCU), sensors, actuators, wireless adapters, and a wireless sensor network (WSN) that interconnect the nodes in the WSN (Dale & Gunik, 2019) (Figure 1). The MCU is a credit card-sized computer that controls the flow of data in the WSN. The MCU is customizable by both hardware and software to meet the purpose of deployment. The data generated by the sensor are unidirectional with the flow of data toward the MCU. The actuator operates in contrast to the sensor by having a unidirectional data flow from the MCU. For example, a temperature sensor monitors and transmits temperature data to the MCU. When high temperature exists in a room, instruction is sent to the actuator located next to the switch to turn on the fan to cool the room.

IoT has applications in various fields but this paper will focus on its application in healthcare.

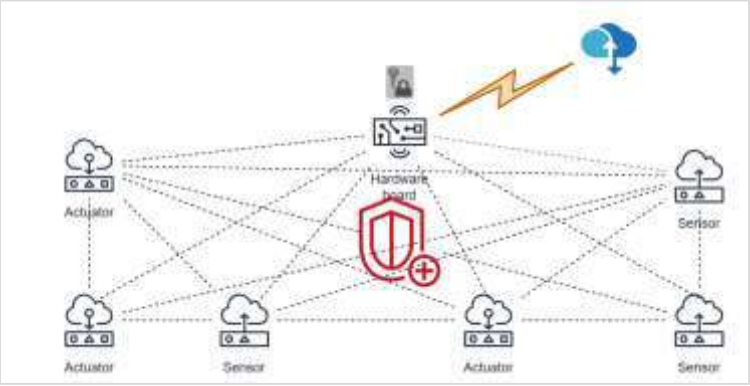

Figure 1: A simple IoT architecture composed of a microcontroller unit, sensors, actuators, and an internet connection to the cloud.

The architecture in healthcare

The application of IoT-WD in healthcare has emerged alongside others such as telemedicine, u-healthcare, e-healthcare, m-healthcare or the Internet of Medical Things (IoMT). The IoT in healthcare is a form of telemedicine that evolved from e-healthcare, to m-healthcare then IoMT (u-healthcare).

The IoT architecture in healthcare consists of the body area network (BAN), intelligent medical server and the hospital management information system (HMIS) (Gelogo et al., 2015). The BAN is a system of sensors attached to the human body to capture the biological signal. To allow patients freedom of movement, Wireless BAN collects patients' health data and forwards them using radio waves to a central node for analysis. The central node is a smartphone that connects to the Internet either by Universal Mobile Telecommunication Service (UMTS/3G), Long Term Evolution (LTE/4G), or the Wireless Local Area Network (WLAN) to forward patient data to a Data Processing Center (DPC). The DPC is a cloud service leased by a hospital to keep patient data. The HMIS is synchronized with the DPC to provide patient information to the nurses and doctors on demand.

Beyond the simple IoT architecture for healthcare discussed, there are more advanced IoT-WD being continually developed for healthcare. We now look at the impact of using this technology in the healthcare sector.

The impact on the healthcare

To investigate the impact of IoT-WD in healthcare, the Technological Impact Analysis (TIA) tool is used as demonstrated by Maddox, Boozer, & Forte (2007). They defined TIA as a simple and important learning tool that analyzes how specific technologies have developed, diffused and affected society in positive or negative ways.

The review conducted using TIA is focused on six questions that form the essence of the methodology. Below are six TIA questions tailored to suit the purpose of this study:

1. What are the historical and social origins of the Internet of Things in Healthcare? In other words, how and why has this technology become prominent?
2. What are key developmental markers in the emergence and diffusion of the Internet of Things in Healthcare?
3. What have been the most positive consequences of IoT in healthcare?
4. What has been the most negative consequence of IoT in healthcare?
5. What have been the unanticipated consequences of IoT in healthcare?
6. What ethical issues must be considered when evaluating the merit of the Internet of Things in healthcare?

Historical and social origins of the IoT in healthcare

Kevin Ashton coined the term "Internet of Things" (Dauwed & Meri, 2019) in 1998, which first appeared in a speech by Peter T. Lewis in 1985. According to Ashton, IoT is a tool used to facilitate the exchange of information over the World Wide Web. The concept is to have every physical object connected through the Internet with unique identifiers. The concept of the network of the smart device was discussed in 1982 at Carnegie Mellon University where

a Coca-Cola vending machine was modified to report its inventory and the temperature of newly loaded drinks. The actual use of IoT was estimated by Cisco System to be between 2008 and 2009. The application of IoT-WD in healthcare was to collect and analyze data for research and monitoring. It was realized in 2015 by Goldman Sachs that IoT could save the United States more than $300 billion annually in healthcare expenditure (Roman et al., 2015).

Development milestone in the emergence and diffusion of IoT in healthcare

The development milestone in the emergence and diffusion of IoT in healthcare began with the "information revolution" in the mid-1940s where the evolution of computer technology was driving the change that would improve lives and extend brainpower. In 1946, John Presper Eckert and John W. Mauchly developed the Electronic Numerical Integrator and Computer (ENIAC). The ENIAC was described as the first general-purpose electronic computer with operational characteristics including memory and arithmetic operation. International Business and Machines Corporation (IBM) launched the personal computer (PC) in 1981 running Microsoft's MS-DOS 1.0, a 16-bit operating system. In 1984 and 1985 the Apple Macintosh and Microsoft Windows were launched respectively. In 1989, the British computer scientist Tim Berners-Lee submitted a proposal for a distributed information system to the European Organization for Nuclear Research (CERN). A year later, a website and a server went live at CERN. In 1994, the development of game consoles such as Sega Saturn and Sony PlayStation had a significant impact and influence on home entertainment. The 2000s brought mass adoption of broadband internet in developed countries providing high-speed internet access to the users (Frangoul, 2018). Today's homes are transforming from smartphones, tablets, virtual assistants, and smart TVs. The merging of the physical and the virtual world brought about the concept of IoT.

Since the evolution of IoT, many disciplines have found the area for its use. The healthcare sector was not an exception.

Positive impact of IoT on healthcare

The application of IoT-WD in healthcare provides benefits to patients, caregivers and physicians. This section highlights benefits namely cost savings and transparency.

Patients with chronic diseases such as cancer, diabetes, lung disease or heart disease incur high medical costs due to continuous visitation to the healthcare centres. These costs may include re-hospitalization, transport, and the time spent out of work for the caregivers to attend to such patients (IEEE, 2021). The technology has the potential to reduce costs by bringing healthcare to the patient. With IoT-WD, vital patient information can be monitored and reported to healthcare providers and caregivers in real-time. Simple tests can be conducted on the patient and communication can be done using the same channel.

With an electronic health record, patients should not have to present health information to every new doctor upon visitation. The health information is shared with multiple doctors concerned while giving the patient insight into their health status and caregivers can monitor

the patient's health status (IEEE, 2021). Consequently, patients' and caregivers' expectations are increased with the quality of service received as the technology is more transparent.

Negative impact of IoT on healthcare

In contrast, drawbacks could affect the users and this section highlights two negative impacts namely privacy and security, and unintended use.

Privacy and security are issues for IoT due to the architectural components sourced from different vendors (IEEE, 2021). Consequently, the device lags behind regular updates and presents vulnerabilities. When the security of an IoT network is breached, the privacy of the patient is violated as data from the IoT-WD becomes insecure.

There are unintended uses of IoT-WD leveraged by persons in authority (IEEE, 2021). For example, the police can implant sensors on lawbreakers to conduct surveillance on their movement, parents can use sensors to monitor their children in school or husbands and wives to monitor each other. In contrast to unintended use, the unanticipated consequences are discussed next.

Unanticipated consequences of IoT in healthcare

Wearable sensors are part of the ecosystem of the IoT in healthcare that was developed to monitor patients for early detection and diagnosis of diseases. IoT-WD is now seen to have unintended consequences such as modification of behaviour and unpredicted challenges faced by regulatory authorities (Schukat et al., 2016). Modification of behaviour is encountered in instances where sensors are worn by both patients and healthy individuals.

As a result of relying on technology, an individual's behaviour may change such as decreased physical activity because of the notion that they are more active than they thought they were (Schukat et al., 2016). For example, certain activities cannot be done by the individual based on the device's advice. Intensive monitoring of individuals using body sensors can lead to anxiety. Users become so obsessed with self-monitoring beyond a healthy level of attention to oneself. IoT-WD used to track other aspects of lifestyle may detect an undiagnosed disease. Reliance on a device bears the risk that the device cannot perform as prescribed on paper in cases where caregivers rely on the IoT-WD for notification but it malfunctions at some point in time.

Challenges faced by regulators are evident in the case of the United States (US) where the US Food and Drug Administration (FDA) declaims the responsibility of regulating wearable sensors designed for lifestyle purposes (Schukat et al., 2016). FDA later requested medical device manufacturers to submit design decisions containing risk analysis due to the increasing security risks that the devices pose. As encountered by the FDA, regulatory authorities should inspect the import and utilization of wearables before reaching the outlets for consumers because of unpredicted challenges. Authorities should indicate how and where data from IoT-WD will be utilized.

Ethical issues of IoT in healthcare

Mittelstadt (2017) discussed ethical issues arising from the utilization of IoT in healthcare that share overlapping discussions in terms of privacy issues with Schukat et al. (2016). The discussion of ethical issues here concerns data and social isolation.

In general, IoT devices generate large volumes and varieties of data describing the health and behaviour of users (Mittelstadt, 2017). Medical research and consumer analytics use much of this data through protocols designed to enable users and third parties to access the dataset. In this case, information privacy is a concern, especially the personally identifiable data released to third parties. As health data are normally considered sensitive both in an ethical and legal sense, information privacy is a central concern for the deployment of IoT devices in healthcare (Mittelstadt, 2017).

Undesired sharing of information violates physical spaces or social relationships and can impede a user's capacity to make decisions because health data begin to profile users as "health impaired" or "at-risk" (Mittelstadt, 2017). The profile also influences the choices made available to third parties with access to the profile.

The use of IoT-WD to manage health conditions can contribute to the social isolation of users because visits from medical personnel and caregivers may be less necessary (Mittelstadt, 2017). Studies involving older people have revealed a concern that IoT will replace personal and social interactions with caregivers rather than supplementing them as promised (Mittelstadt, 2017). A different mode of interaction such as robots or social networking is not sufficient to replicate face-to-face interaction that contributes to the mental health and well-being of patients. This is an ethical problem concerning the nature and scope of medical and healthcare practitioners.

The six TIA questions tailored to suit the purpose of this study have been limited by judgment to suit the requirement of where this article is intended to be published. We now analyze factors from the theoretical adoption model influencing the adoption of IoT in healthcare in developing countries using a Systematic Literature Review (SLR).

Systematic literature review

To investigate these factors, SLR has been conducted as done by Carcary et al. (2018) who followed the 8 steps proposed by Okoli (2015) to extract data for secondary analysis of the literature. During the investigation, several theoretical adoption models were encountered such as the Technology Acceptance Model (TAM), Hedonic-Motivation System Adoption Model (HMSAM), Unified Theory of Acceptance and Use of Technology (UTAUT), Laddering technique, and Means-End methodology applied in various studies.

TAM has an ample number of applications within technology acceptance research and thus has received significant empirical support (Adapa et al., 2018). It centres around two core constructs; perceived ease of use and perceived usefulness. 'Perceived Ease of Use' is the degree to which the user expects the target system to be free of effort and 'Perceived

usefulness' defines the probability of using a system to increase job performance in an organization (Davis, 1989). HMS is the adoption model used to investigate motivation systems (HMS). HMS are systems used for pleasure rather than productivity as opposed to the Utilitarian-Motivation Systems (UMS) (Lowry et al., 2013). The Laddering methodology is used to discover and understand the fundamental values of factors influencing the adoption of a particular technology through an interview while the Means-End methodology focuses on consequences leading to the valued factor (Adapa et al., 2018).

UTAUT was formulated by Venkatesh et al. (2003) with four factors namely 1) performance expectancy (PE), 2) effort expectancy (EE), 3) social influence (SI), and 4) facilitating conditions (FC) (Venkatesh et al., 2003). The second version of the UTAUT model known as the UTAUT2 extends UTAUT by three additional factors of adoption; 5) hedonic motivation (HM), 6) price value (PV) and 7) habit (HA).

Table 1: Hypothesis and UTAUT2 factor mapping

UTAUT2 Factors		**Hypothesis**	
F1	PE	H1	The simplicity and effectiveness of providing healthcare using IoT-WD will positively influence the use of the technology in developing countries
F2	EE	H2	The least amount of effort required to use IoT-WD in healthcare will positively influence the use of the technology in developing countries
F3	SI	H3	Positive social influence regarding the use of the IoT-WD in healthcare will influence the use of the technology in developing countries
		H4	Negative social influence regarding the use of the IoT-WD in healthcare will affect the use of the technology in developing countries
F4	FC	H5	Available technical expertise to support the use of IoT-WD in healthcare will influence the use of the technology in developing countries
		H6	Availability of infrastructure to support the use of IoT-WD in healthcare will influence the use of the technology in developing countries
F5	HM	H7	The belief of experiencing fun in the use of IoT-WD in healthcare will influence the use of the technology in developing countries.
F6	PV	H8	The cost of using an IoT-WD in healthcare will influence the use of the technology in developing countries.
F7	HA	H9	Prior experience of using technology will influence the use of IoT-WD in developing countries.

Hypotheses are derived from the UTAUT2 factors (Table 1) and tested using a secondary data collection process done by Carcary et al. (2018). In this study, 8 steps approach proposed by Okoli (2015) was used to collect qualitative data from the literature as follows:

1) Purpose of the literature review: The author tries to synthesize relevant theories by examining several peer-reviewed journal articles in the stream.
2) Protocol and training: The systematic literature search is focused on synthesizing theories to categorize under H1, H2, H3, H4, H5, H6, H7, H8, and H9. The hypotheses are units of analysis in a concept-matrix table as demonstrated by Webster & Watson (2002).
3) Searching for the literature: The following terms should appear within the article title, abstract, and keywords; *IoT-device OR wearable device AND adoption AND*

healthcare AND developing countries OR low-middle income countries. The literature search is based on articles published between 2011 and 2021 inclusive on RefSeek.com, Google Scholar and Researchgate.

4) Practical screen: Based on the search criteria defined in the previous step, the author managed to collect 33 articles but the initial screening of abstracts and keywords resulted in the exclusion of 29 due to research background. The use of backward and forward citation tracking resulted in 89 papers being reviewed.
5) Quality appraisal: 10 papers evaluated are of acceptable quality based on their source.
6) Data extraction: From each paper reviewed, theories are synthesized, summarized and classified.
7) Synthesis of study: A concept-matrix was created to map the theories extracted on the row heading to the hypothesis with a cluster of UTAUT2 factors on the column heading. An indicator is used to represent the relationship between theories and hypotheses as a way of indicating the factors.
8) Writing the review: The final step provides a qualitative analysis of the data in the concept-matrix table and concludes the adoption factors of the IoT-WD in healthcare for developing countries.

Factors that influence adoption of IoT

This section contains the findings from the SLR showing factors that influence the adoption of IoT-WD in healthcare in developing countries. The findings using SLR are compiled in the concept matrix in Table 2.

Table 2: Data from SLR in a concept matrix.

Sr.	**Authors**	**PE**	**EE**	**SI**		**FC**		**HM**	**PV**	**HA**
		H1	*H2*	*H3*	*H4*	*H5*	*H6*	*H7*	*H8*	*H9*
1	Basholli et al., (2017)									X
2	Vo et al., (2011)	X				X	X			
3	Levine, (2017)	X			X	X				X
4	Basholli et al., (2014)	X					X		X	
5	Basholli et al., (2015)								X	
6	Darwish & Hassanien, (2011)	X							X	
7	Kakria et al., (2015)	X								
8	Binaymin & Hoque, (2020)	X		X		X	X	X		X
9	Rubin & Ophoff, (2018)	X								X
10	Toycan, (2018)					X	X			X
	Frequency	*7*	*0*	*1*	*1*	*4*	*4*	*1*	*3*	*5*

Performance Expectancy: The use of IoT-WD in providing healthcare in developing countries proved to be simple and effective. According to Table 2, H1 seemed to be common where 7 out of 10 articles indicate PE as the most likely factor influencing the adoption of IoT-WD in developing countries. Vo et al. (2011) proved that the use of technology to deliver healthcare remotely is an effective way of overcoming the barrier to care for communities located in rural and remote areas. Levine (2017) affirms that the investment in IoT-WD is worthwhile on mass scales in poor areas. Basholli et al. (2014) discussed technologies that support IoT-WD and claimed that a WSN will suit the health needs of developing regions where the number of patients is higher than the specialists. Darwish & Hassanien (2011) explain the importance of the BAN in medicine to minimize the need for caregivers and help

the chronically ill and elderly people live independent lives besides providing quality care. Kakria et al. (2015), Binaymin & Hoque (2020), and Rubin & Ophoff (2018) all indicate H1 to be a factor for developing countries.

Effort Expectancy: Having the least amount of effort to use IoT-WD in developing countries cannot be proven due to limited research done in this area in developing countries. Most of the papers reviewed for developing countries are based on non-empirical studies except Rubin & Ophoff (2018) who have done an investigation for health and fitness wearable devices in South Africa but are unable to prove effort expectancy. Darwish & Hassanien (2011) identified challenges and research problems encountered with the use of wearable and implantable sensors to assume design improvements required to influence the adoption of wearable in healthcare.

Social Influence: According to Binaymin & Hoque (2020), positive social influence (H3) can be a factor that influences the adoption of wearable devices in healthcare when someone influential such as parents, relatives, friends, co-workers, family, or media persuading an individual to engage in a specific action. The negative social influence (H4) can prevent the adoption of wearable devices in healthcare (Levine, 2017). These negative influences are present due to the challenges that arise in the deployment of IoT-WD in healthcare such as ethical and privacy issues, lack of standardization, and lack of value-added individualization.

Facilitating Conditions: The availability of technical specialists (H5) will influence the adoption of IoT-WD in developing countries as confirmed by Vo et al. (2011), Levine (2017), Binaymin & Hoque (2020), and Toycan (2018). Vo et al (2011) discussed the benefits of telemedicine using the existing mobile wireless platform to provide healthcare service to the remote population in Taxes which fits developing countries where the bulk of the population is located in remote or rural areas. The author assumes technical specialists are abundant where there is existing technological infrastructure. Levine (2017), Binaymin & Hoque, (2020), and Toycan (2018) situate their research in developing countries and all indicate the necessity of having a technical specialist. The availability of technological infrastructure (H6) can influence the adoption of IoT-WD in developing countries. As discussed by Vo et al. (2011), infrastructure is a platform to launch telemedicine services. Basholli et al. (2014) and Toycan (2018) confirm that without an infrastructure a barrier is created to adopt the technology in healthcare. Binaymin & Hoque (2020) modified the UTAUT2 by including two additional factors; government health policy and trust to understand the drivers of wearable health technology. From their findings, wearable device depends on the support of wireless networks and internet services to provide such healthcare services.

Hedonic Motivation: The belief that experiencing fun using IoT-WD will influence the use of the technology in developing countries. From the review, Binaymin & Hoque (2020) supports this factor with their findings. The other articles do not indicate this factor because the IoT-WD was not in actual use in their research or the technology is used in conditions that negate the experience of having fun such as discovered by Rubin & Ophoff (2018).

Price Value: The cost involved in using IoT-WD in healthcare will influence the use of the technology in developing countries as demonstrated in 3 out of 10 articles reviewed. Basholli et al. (2014) consider developing countries to be using wearable technology because of affordability. The paper argued that a good system architecture can suit the economic situation in a developing country. In another article, Basholli et al. (2015) analyzed the overall cost of living expenses in Kosovo a developing country and found living expenses to exceed the minimum cost of treatment for chronic conditions. They concluded the application of a wearable technology platform is a feasible and affordable method of dealing with chronic diseases. Darwish & Hassanien (2011) state that wearable and implantable WSN is a tool to reduce the cost of healthcare but improvement in the design will influence adoption.

Habit: Prior experience in using technology will influence the use of the IoT-WD in developing countries. According to Table 2, 6 out of 10 papers reviewed support the factor. Basholli et al. (2017) observed clinical centres in Kosovo are still using old and traditional health offering tools and equipment because they are accustomed to the use while there are high-tech healthcare devices available on the market. Levine (2017) discussed the challenges that might arise when deploying wearable technology to improve healthcare in developing countries. Low literacy rate, absence of a culture of healthiness, the culture of mistrust of technology, low health and tech literacy, poor knowledge of integrating technology, and failure to appreciate the impact of social determinants of health are among the challenges. Findings from Binaymin & Hoque (2020) indicate prior learning or experience of using a specific technology has a positive effect on the behavioural intention in the use of wearable technology. Rubin & Ophoff's (2018) study in South Africa showed habit is one of the two factors that influence the adoption of such technology.

Therefore, the findings suggest the factors of UTAUT2 influencing the adoption of wearable technology in healthcare in developing countries could be PE, SI, FC, HM, PV and HA. We now discuss a system architecture that is suitable for the healthcare system in PNG.

An architecture for PNG

IoT-WD in healthcare requires an existing network infrastructure to support its operation. A WSN is required for the technology to transform the healthcare sector by shifting focus from hospital-centred to patient-centred. Basholli et al. (2015) and Basholli et al. (2017) discussed the significance of having a sensor-based network with a mobile node using a WSN. Basholli et al. (2014), Vo et al. (2011), Basholli et al. (2014), and Darwish & Hassanien (2011) all discussed the suitability of a wireless network for such technology in healthcare.

In PNG, mobile technology infrastructure has reached some parts of the rural area compared to TCP/IP infrastructure. The Universal Mobile Telecommunication System (UTMA/3G) and Long Term Evolution (LTE/4G) are centred mainly in urban areas while Global System for Mobile Communications (GSM/2G) is common in rural areas.

The proposed WSN architecture for PNG that can support the deployment of IoT-WD in healthcare is the Long Range Physical (LoRA PHY) wireless module and LoRaWAN

protocols. LoRa PHY is a low-powered radio communication device with batteries that have a lifespan of 2 to 10 years. De Carvalho Silva et al. (2017) proposed a LoRa PHY network architecture that is similar to the telecommunication infrastructure in PNG. However, in the proposed architecture for PNG (Figure 2), base stations can be replaced by LoRa gateways deployed on telecommunication towers by lease agreements with telecommunication companies. The coverage range of a LoRa gateway is 45 kilometres (km) in radius, especially in the rural area where the bulk of the population is compared to urban the range will be less than 5 km. Sensors should be within the coverage range to transmit data to the LoRa gateway then the gateway forwards the data using GSM (in rural areas) or UTMA/LTE (in urban areas) to the HMIS via the Internet. Mesh topology configurations can support users who are slightly out of the coverage area.

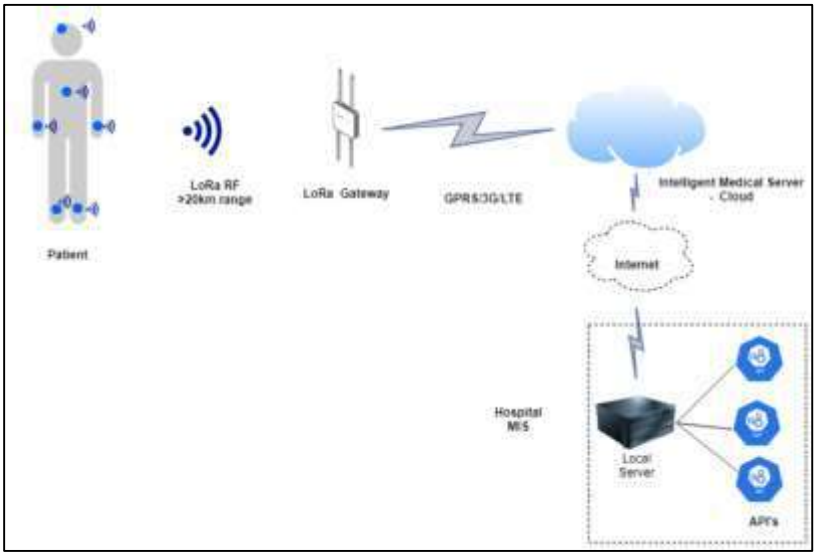

Figure 2: Proposed IoT-WD architecture for PNG

A separate paper will demonstrate the proposed architecture in more detail while comparing LoRa with other low-powered wide-area network protocols.

Conclusion

This paper discussed the application of IoT-WD in healthcare for PNG. The discussion began with the context in which the topic is based by reviewing literature about the application of IoT-WD in other countries and the stand of the PNG government for healthcare in the PNG MTDP III. The general architecture of IoT and the architecture that supports applications in healthcare were discussed. The TIA was used to analyze the impact of IoT by conducting a review based on the six TIA questions. The SLR was used to analyze literature to evaluate factors borrowed from UTAUT2 that motivate the use of IoT-WD in healthcare in developing countries which is a study PNG can be an example. The paper finally discussed an IoT-WD architecture for healthcare services in PNG.

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Secret sharing schemes from topological spaces

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Abstract

A secret sharing scheme is a method of dividing up a secret into shares, and the shares distributed to participants, such that only authorized subsets of participants can reconstruct the secret when they combine their shares. Many secret sharing schemes have been proposed, since their introduction by Blakley (1979) and Shamir (1979). In Bouroubi et al (2019), set partitions were suggested as a basis for creating a secret sharing scheme. In this paper, we propose several schemes based on the partition of a topological space.

Keywords: secret, sharing, scheme, topological space

Introduction

A secret sharing scheme (SSS) is a method of subdividing a secret into shares and distributing the shares among a set of participants, such that only authorized subsets of participants can reconstruct the secret when they combine their shares. When an unauthorized subset of participants combines their shares they should not be able to reconstruct the secret.

Let X be a non-empty finite set. A topology on X is a set of subsets τ of X, such that X and $\emptyset$ belong to τ, unions of sets in τ are in τ and intersections of elements of τ are in τ. Elements of τ are called open sets. The ordered pair (X, τ) is then called a topological space. Since X is finite, such a space is also called a Kolmogorov space.

A basis for a topological space is a collection of open subsets of the topological space, such that every open subset can be expressed as a (possibly empty) union of basis subsets.

A subset D of X is called dense if D has a nonempty intersection with every nontrivial open set in X.

For example, suppose X = 12345 and $\tau = \{\emptyset, X, \{1, 2, 3\}, \{3, 4, 5\}, \{3\}\}$. Then the set {2, 3, 4} is dense since it intersects non trivially with each nontrivial open set in the space X. Also, {1, 3, 5} is dense.

As another example of a topological space, let X = R be the set of real numbers. An open interval in R is a set (a, b) of real numbers x, such that $a < x < b$. Define a set A to be open, if, for each element p in the set A, there is an open interval (a, b), such that $p \in (a, b) \subseteq A$. The set of all open sets defined this way is a topology on R. So R with all such sets is a topological space. ($\emptyset$ is vacuously open).

If (X, τ) is a topological space and $A \subseteq X$, then a topology can be defined on A, by

$$\tau A = \{A \cap O : O \in \tau\}.$$

τA is called the subspace topology of A, and $(A, \tau A)$ is called a subspace of (X, τ).

A group consists of a set G /= ∅ and a binary operation ∗: G × G → G that is associative, for which there is an identity element, say e, and such that every element in G has an inverse. By associative we mean that a ∗ (b ∗ c) = (a ∗ b) ∗ c for every three elements a, b, c in G. By identity element we mean there is an element e in G such that a ∗ e = a = e ∗ a for every element a in G. By an inverse element, we mean that for every element a in G there is an element a−1 also in G such that a ∗ a−1 = e = a−1 ∗ a. a−1 is called the inverse of a in G. A subset H of a group G is a subgroup of G if it is a group with respect to the binary operation ∗ on G. In this case, we write H ≤ G.

A group G is said to act on a nonempty set X when there is a map ϕ: G × X → X such that (1) ϕ(e, x) = x for every e in G, and (2) ϕ(g, ϕ(h, x)) = ϕ(gh, x) for all g, h in G. The two conditions may be rewritten as ϕ(e, x) = e.x = x and (2) ϕ(g, ϕ(h, x)) = g.(h.x) = (g.h).x. If g ∈ G and x ∈ X then g.x is called the action of g on x. If G acts on X we call X a G-set.
If x and y are two elements in a G-set X, for some group G, then y is in the orbit of x in X, denoted Orb(x) if there is a group element g such that g.x = y.

It is known that (Fraleigh, 2004):

Theorem 1.1. Let G be a group, and X be a G-set. Then the set of orbits in X forms a partition of the set X.

If H is a subgroup of a group G and a ∈ G, a left coset of H with respect to a, is the set

$$aH = \{a * h : h \in G\}.$$

Right cosets are similarly defined. If aH = Ha for all elements a in G, then H is called a normal subgroup. The set of all cosets of a normal subgroup H is denoted by G/H. It turns out that if we define a binary operation (aH).bH) = (a∗ b)H on G/H then G/H becomes a group, called the coset group of G modulo H, or the factor group of G modulo H (Milne, 2021). Here, the identity in this group is H, and the inverse of any element aH is a−1H. Also, if we define a ≈ b iff a and b belong to the same left coset, then ≈ is an equivalence relation on G. Indeed, the left cosets form a partition of G. By Lagrange's theorem, any two left cosets have the same cardinality (Milne, 2021).

In the next section, we discuss creating secret sharing schemes based on finite topological spaces. As far as we know there are no secret sharing schemes created or suggested based on topological space.

Essentially, the secret will be the topology τ on X. However, as we will see later, there are subsets of X that will determine the topology uniquely. Such a subset will be called a share-set. The shared space will be the set of subsets in the share set. Such schemes will be secure because the number of topologies on a large-sized set is not trivial. Suppose that T (n) is the number of topologies on a set of n elements. For small values of n, T (n) has been estimated as follows: T (1) = 1, T (2) = 4, T (3) = 29, T (4) = 355, T (5) = 6, 942, T (6) = 209, 527, T

(7) = 9, 535, 241, (Chaterji, 1966). According to Krishnamurthy (1966), T (n) ≤ 22n−2, n ≥ 1. As yet there is no known general method for obtaining T (n).

Secret Sharing Schemes

Secret sharing schemes are used to increase the security of critical data. This involves the sharing of a secret key between a group of participants by a dealer, such that specific subgroups of the shareholders can recover the secret by pooling their shares. In a threshold (t, n) scheme a dealer distributes a secret value S to 'n' players such that at least t players are required to reconstruct the secret.

The first secret sharing schemes were introduced independently by Blakely (1979) and Shamir (1979). Blakely's scheme was based on the fact that any n nonparallel (n − 1)-dimensional hyperplanes intersect at a specific point. One of the coordinates of this point is taken to be the secret. Each participant is given enough information to define a hyperplane: the secret is then calculated by determining the point of intersection of the hyperplanes, and then taking a specified coordinate of the point of the intersection.

Shamir's scheme is a (t, n) threshold scheme. The scheme relies on the fact that it takes t points to define a polynomial of degree t − 1. The secret is the first coefficient. The shares are the coefficients of the polynomial. When t participants combine their shares, there will be enough information to construct a t − 1 degree polynomial.

Amos Beinel's survey (Beinel, 2011) lists numerous schemes, and we refer the reader to this article for more examples of such schemes.

Secret sharing schemes based on basis sets

In this case, the secret is τ, whereas the shares are the elements of the basis, B. Often, τ can be uniquely determined by a smaller set of subsets of X, for example, the basis.

Example 2.1. Suppose that X = {1, 2, 3, 4, 5, 6}. A topology on X is
τ = {X, ∅, {1, 2, 3, 4, 5}, {1, 2, 3, 4}, {3, 4, 5, 6}, {3, 4, 5}, {1, 2, 5}, {1, 2}, {3, 4}, {5}}.

{{5}, {1,2}, {3,4}, {3,4,5,6}} is the secret.

A basis for this topology, is B = {{5}, {1, 2}, {3, 4}, {3, 4, 5, 6}}. Note that this is a minimal basis, in that no subset of this set is also another basis for the topology. B is the secret.

The above scheme can be modified as follows:

Secret sharing schemes based on Cosets

Suppose that X is a group, and H is a normal subgroup of X. Then the set of left cosets of H partition X. We take the topology in this case to be that generated by these cosets. That is, every element of the topology can be generated, by taking unions, of cosets. This set of cosets is the share-set. That is, the set of left cosets forms the basis for the topology.

Example 2.2. Let X = {0, 1, 2, 3, 4, 5, 6, 7}. This is a group with addition modulo 8, as shown in the group table below:

Table 1: Group with addition modulo 8

$+_8$	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*
0	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*
1	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*0*
2	*2*	*3*	*4*	*5*	*6*	*7*	*0*	*1*
3	*3*	*4*	*5*	*6*	*7*	*0*	*1*	*2*
4	*4*	*5*	*6*	*7*	*0*	*1*	*2*	*3*
5	*5*	*6*	*7*	*0*	*1*	*2*	*3*	*4*
6	*6*	*7*	*0*	*1*	*2*	*3*	*4*	*5*
7	*7*	*0*	*1*	*2*	*3*	*4*	*5*	*6*

A subgroup in this case is H = {0, 2, 4, 6}. Its cosets are as follows:

1. 0 + H = H = 2 + H = 4 + H = 6 + H = {0, 2, 4, 6}.
2. 1 + H = 3 + H = 5 + H = 7 + H = {1, 3, 5, 7}.
3.

There are only two cosets, but these form the basis or share-set. That is, there are only two shares in this scheme. The secret, in this case, is {{0, 2, 4, 6}, {1, 3, 5, 7}}.

Secret sharing scheme over a subspace topology

Recall that if (X, τ) is a topological space, then a set D ⊆ X is dense, if D has a non-empty intersection with every non-empty open set in the space. The set τD consisting of all the intersections of D with the elements of τ forms a topology on D. That is, (D, τD) is itself a topological space, often referred to as a subspace of (X, τ). In this case, τD is the secret, and the share-set is a minimal basis for τD.

Example 2.3. Let X = {1, 2, 3, 4, 5, 6}. Let τ = {X, ∅, {1, 2, 3, 4, 5}, {1, 2, 3, 5, 6}, {1, 2, 3, 5}, {1, 2, 3, 6}, {3, 4, 5, 6}, {1, 2, 3}, {3, 4, 5}, {3, 5, 6}, {3, 5}, {3, 6}, {3}, {5}, {6}}.

A dense set is D = {2, 3, 5, 6}. To create a topology on D, we take the intersection of D with every nonempty open set and then add on the empty set. We get

τD = {D, ∅, {2, 3, 5}, {2, 3, 6}, {3, 5, 6}, {2, 3}, {3, 5}, {3, 6}, {5, 6}, {3}, {5}, {6}}

It is easy to verify that τD is a topology on D. We now need a basis for this topology, which will become the secret. Such a set is a basis for the subspace topology

B = {{3}, {5}, {6}, {1,2, 3}}

The secret in this case is the set B.

Secret sharing schemes based on group actions

Suppose that G is a group and X is a G-set. By Theorem 1.1, X is partitioned by the action: specifically, the orbits induced by the action will partition X. These orbits will form the basis,

and therefore the share-set of the secret sharing scheme. The set of orbits of X under the action of G, is denoted by X/G.

Example 2.4. Let X = {1, 2, 3, 4, 5, 6}. The set of permutations of the elements of X form a group, denoted by S6 and called the symmetry group on 6 elements. Suppose now that we define the permutation σ: X → X, as follows:

$$\sigma = \begin{matrix} 1 & 2 & 3 & 4 & 5 & 6 \\ 2 & 4 & 6 & 1 & 5 & 3 \end{matrix}$$

This means that: σ(1) = 2, σ(2) = 4, etc. Then with regard to orbits, Orb(1) = {1, 2, 4}, Orb(3) = {3, 6} and Orb(5) = {5}. These orbits partition X. But this gives us a basis for a topology. That is the basis is B = {{1, 2, 4}, {3, 6}, {5}}, and this forms the secret.

Example 2.5. Let X = {1,2,3,4,5,6,7,8,9,10,11,12}. A basis is {{1,2}, {3,4}, {5,6},{7,8}, {9,10,11,12}}. The secret in this case is B = {{1,2}, {3,4}, {5,6},{7,8}, {9,10,11,12}}.

Security of the Above Schemes

Various secret sharing schemes were developed since Shamir (1979) proposed one in 1979. The security of the above secret sharing schemes proposed is proportional to the number of topologies that can be defined on a set of n elements, n being a positive integer. In each case, the secret is the topology whereas the set of shares is the basis of the topology. In this section, we will consider the security of these secret sharing schemes based on these assumptions.

According to Krishnamurthy (1966), $T(n) \leq 2^{2^n-2}$, $n \geq 1$. As yet there is no known general method for obtaining $T(n)$.

It has been determined that the number of distinct topologies on a set of n elements, for $1 \leq n \leq 10$, is as follows (see [16]):

Table 2: Number of distinct topologies on a set of n elements

n	Distinct topologies	Inequivalent topologies
0	1	1
1	1	1
2	4	3
3	29	9
4	355	33
5	6942	139
6	209527	718
7	9535241	4535
8	642779354	35979
9	63260289423	363083
10	8977053873043	4717687

In forming a secret sharing scheme based on one of the methods given above, we suggest that a fairly large set be used, as the base set. As can be seen in the above table, for n = 10, the

number of distinct topologies on such a set is already astronomical. We suggest that this therefore makes such a secret sharing scheme secure. The challenge would be to find a basis for the chosen topology.

Conclusion

In this paper we have shown how to create a secret sharing scheme from a finite topological space, using the basis as the share-set. Although a basis for a topology is not unique, a topology generated by a basis is unique. But how does one determine a basis for a given, finite but very large topology? We believe that this is a question worth pursuing.

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