Assessment of Biomedical Equipment in the Government Hospitals of Bagmati Province, Nepal

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ABSTRACT

Biomedical equipment is crucial in healthcare management and public health by aiding disease detection and treatment. The COVID-19 pandemic highlighted the importance of biomedical equipment, prompting the development of a digital platform for real-time data collection on biomedical devices. The research aims to evaluate the condition of biomedical equipment at the government hospitals in the Bagmati Province of Nepal. The study analyzed 22 government hospitals in Nepal's Bagmati Province, collecting data on biomedical equipment types, num-bers, and statuses using the BEMS portal and comparing the data to determine the best and least equipped hospitals. There are 7617 biological articles in 22 hospitals in Bagmati Province; TUTH has the highest, with 1778 pieces. Autoclaves, bio-chemistry analyzers, ECG machines, x-ray machines, and patient monitors are standard medical equipment. 5.65 % of the equipment is inoperable, compared to an average of 94.34% functioning correctly. The study highlights how real-time data might improve biomedical equipment replacement and maintenance at govern-ment hospitals in the Bagmati area of Nepal. It emphasizes the need for improved data collection and reporting by implying that this data can support well-informed decision-making and resource allocation.

Keywords: Biomedical equipment, Healthcare technology, Hospitals, BEMS, Nepal

Introduction

Biomedical technology is a set of medical, biological, and pharmacological tools. It encompasses various medical equipment and technology for diagnostic, therapeutic, and monitoring purposes. Biomedical equipment is used in multiple medical fields, including medical technology, to automate clinical operations such as vital sign moni-toring, breathing monitoring, and electrosurgery. It also employs innovative forms of therapy such as micro-waves, ultrasounds, and magnet therapy. In addition, biomedical equipment is utilized in labs for sample analysis, bacterial culture, freeze-dry dehydration, and electrolysis-based compound separation. (Carelabs, 2024; Edibon. com, n.d.; WHO, n.d.). In medicine, this equipment is used in disease prevention, diagnosis, treatment, and rehabilitation, as well as the organizational and supportive systems within which care is provided and im-proving the overall standard of care. (Daley, n.d.; Herndon, Hwang, & Bozic, 2007; Robbins, 1978). The equipment is vital in hospitals, clinics, and research laboratories. Imaging machines [X-ray, Magnetic Resonance Imaging (MRI), Computed Tomography scan (CT scan)], patient monitors, defibrillators, infusion pumps, and surgical instruments are among them. Human diseases and medical disorders are treated using biomedical equipment, which also aims to give better quality care by providing possibilities for less intrusive treatment, faster diagnosis, shorter hospital stays, and quicker rehabilitation through precise and trustworthy data, improving pa-tient care and overall healthcare outcomes. (WHO, 2011). Healthcare practitioners diagnose, treat, and monitor patients using these technologies. Using technologies, they can deliver higher-quality care, reduce errors, and enhance patient outcomes. (Ministry of Health and Population, 2006).

The actual number of medical devices in different countries is difficult to measure due to differing levels of healthcare infrastructure and the vast diversity of devices utilised. An estimated 2 million different types of medical devices are classified into over 7000 generic device groups.(WHO, 2011). The expanding population and improving healthcare infrastructure drive the need for medical equipment in low- and middle-income countries. WHO estimates that over 50% of medical equipment in developing countries is not functional, is not being utilised correctly, and is not adequately maintained(Mediterranean & Session, 2006). The availability and quality of medical devices in these areas are frequently limited by variables like infrastructure, qualified people, and access to replacement parts and support.(Vasan & Friend, 2020).

The pandemic has posed tremendous challenges to healthcare systems worldwide. (Rücker et al., 2021). During and after the COVID-19 pandemic, the pandemic demonstrated the enormous capabilities of biomedical equipment that can be employed to modify the current world picture. Medical gadgets and accessories for es-sential healthcare, quarantine facilities, surveillance systems, and related digital technologies were in high demand, and accurate information was rarely available in

health facilities. The NHRC of the Government of Nepal and the MOT discovered that major government hospitals in Nepal had shortages of vital biomedical equipment such as ventilators and oxygen concentrators at the peak of the COVID-19 epidemic. (GoN, NHRC, 2021). COVID-19 has significantly impacted the delivery of healthcare services, and digital technologies have shown potential for advancing the development of healthcare facilities and services(Chandra et al., 2022). The COVID-19 epidemic in recent years has brought to light the vital role that biomedical instruments play in public health. (Khot, 2020).

Nepal has been experimenting with e-health efforts for about a decade, including telemedicine pilot projects, hospital collaborations, and rural telemedicine programmes. The Ministry of Health and Population has also launched mobile phone-based information distribution and created a National Health Communication Policy 2012. Partners and stakeholders assist with small-scale e-health initiatives.(Nepal, 2017; Ramshahpath, 2012). During the pandemic, the capacity of the government to prepare for the acquisition, diffusion, provision of services and administration of biomedical equipment was impeded owing to a lack of exact data on biomedical devices in hospitals under the government of Nepal.

During the pandemic, the government's capacity to prepare for the acquisition, diffusion, provision of services, and administration of biomedical equipment faced challenges due to a lack of exact data on biomedical devices in hospitals under the government of Nepal.

Based on the following issue, a specific portal regarding biomedical equipment, the digital BEMS portal, was developed and used to collect information on the numerous biomedical devices available at national, provincial, and local-level institutions. The study's objective is to evaluate the condition of biomedical equipment at gov-ernment hospitals in Bagmati Province, Nepal. This paper advocates for tracking biomedical equipment in cen-tral/federal and provincial hospitals and recommends strengthening curative health care in future natural and anthropogenic catastrophes.

2. Materials and Methods

A cross-sectional survey method was used for data collection using a BEMS using a portal (https://bems.mohp.gov.np/) and observational study, particularly on the type, number, operational status, non-operational status, manufacturer's name, occupied units, critical care equipment, and supplier's name of biomedical equipment from central/federal, provincial and local government hospitals located in Bagmati Province, Nepal.

The sample size for this study included 29 hospitals, consisting of 16 central hospitals and 13 provincial gov-ernment hospitals. Among these hospitals, Madan Bhandari Academy of Health Sciences (Hetauda Hospital) held a unique position, serving both as a local government hospital and a provincial hospital, thus bringing the total count to 29 hospitals. Only 22 hospitals could provide information for several reasons, including constrained access to biomedical engineers (BMEs) and inadequate involvement from biomedical equipment technician (BMETs) and hospital officials. The following are the twenty-two hospitals where data were gathered for the study:

The medical director, medical superintendent, BMEs and BMETs in each hospital were first given a brief over-view of the research before the collection of data, and they were then informed about the goals of the digital health portal. Each hospital's BME and BMET received training on uploading the necessary data using the BEMS portal. To further assure the proper implementation of the study, we carried out several responsibilities, such as validating the data entered in the portal through the Mission Oxygen Team (MOT) technical, field coordinator, and MOT management. The phase of data collection lasted from December 2022 to July 2023.

The data was obtained, and Microsoft Excel was extracted and analysed it. The data were analysed using descriptive statistics, including the mean, median, and percentage. A comparative analysis determined which hospitals held the most and least equipment, occupied equipment for each type, and operational and non-operational equipment. Additionally, each hospital's proportion of occupied equipment was determined and compared. The total number of operational and non-operational critical care devices and the proportions of operational and non-operational devices were thoroughly analysed. Additionally, a thorough comparison between provincial government hospitals and central government hospitals was also carried out.

Before data collection, ethical approval was acquired from the NHRC ethical review board (ERB) dated May 4, 2022 (Ref: 076/077/21). Additionally, I received formal and administrative approval for the studies.

Table 1 *Hospitals under Federal and Provincial Government*

S. N	Hospitals under the Federal Government	Hospitals under the Provincial Government
1	Bhaktapur Cancer Hospital (BHCH)	Bajrabarahi Chapagaun Hospital (BCH)
2	Naradevi Ayurveda Hospital (NAH)	Bhaktapur Hospital (BKH)
3	B.P Koirala Memorial Cancer Hospital (BKMCH)	District Hospital Ramechhap (DHR)
4	Bharatpur Hospital (BH)	Charikot Hospital(CKH)
5	Human Organ Transplant Centre-Shahid Dharmabhakta National Transplant Centre (HOTC)	Trishuli Hospital (TH)
6	TU Teaching Hospital (TUTH)	Sindhuli Hospital(SH)
7	Sukraraj Tropical & Infectious Disease Hospital (STIDH)	Ratnanagar Bakular Hospital (BRHC)
8	Civil Service Hospital (CIH)	Tokha Hospital (TOH)
9	Patan Academy of Health Sciences Hospital (PH)	Methinkot Hospital (MEH)
10	Mental Hospital (MH)	Chautara Hospital (CH)
11	Sahid Gangalal Hospital (SGH)	Madan Bhandari Academy of Health Sciences -Hetauda Hospital (MBAHS)

Table 2 *Number and type of equipment in each Hospital*

Hospitals	**Types of Equipment**	**Total number of Equipment**
BCH	37	90
BHCH	36	104
BKMCH	77	1101
CH	29	58
DHR	27	42
BH	22	89
NAH	33	220
PH	189	1207
HOTC	56	203
SH	38	145
MBAHS	60	583
STIDH	49	0
TRUTH	321	1778
TH	71	398
CIH	22	136

SGT	24	72
TOH	34	74
CKH	45	169
MH	18	20
MEH	15	59
BKH	52	1040
BRHC	13	30

Table 3 *Prevalence of operational and non-operational equipment in the hospital of Bagmati Province*

Hospital	Total number of operational equipment	Total number of non-operational equipment	Total number of equipment	%Operational	% Non-Operational
BCH	80	10	90	88.89%	11.11%
BHCH	86	18	104	82.69%	17.31%
BKMCH	1101	0	1101	100.0%	0.00%
CH	52	6	58	89.66%	10.34%
DHR	27	15	42	64.29%	35.71%
BH	69	20	89	77.53%	22.47%
NAH	184	36	220	83.64%	16.36%
PH	1050	156	1207	86.99%	13.01%
HOTC	189	14	203	93.10%	6.89%
SH	91	54	145	62.76%	37.24%
STIDH	N/A	N/A	N/A	N/A	N/A
MBAHS	582	1	583	99.82%	0.17%
TH	398	0	398	100%	0.00%
CIH	129	7	136	94.85%	5.15%
SGT	47	25	72	65.28%	34.72%
TRUTH	1754	24	1778	98.65%	1.40%
TOH	52	22	74	70.27%	29.73%
CKH	155	14	169	91.72%	8.28%
MH	11	9	20	55.0%	45.0%
MEH	N/A	N/A	59	N/A	N/A
BKH	1040	0	1040	100%	0.00%
BRHC	30	N/A	30	100%	N/A

Table 4 *Prevalence of operational and non-operational equipment in the hospital of Bagmati Province*

Hospitals	FDA Class	Number of non-operational critical care equipment in Hospitals	Number of operational critical care equipment in Hospitals
Ventilator	Class II/III	61	250
Cardiac Mon-itor	Class II	0	2
Defibrillator	Class III	6	66
Infusion Pumps	Class II	18	232
Hemodialysis machines	Class II	0	137
Pulse oxime-ter	Class II	8	81
EEG Monitors	Class II	1	2
Blood Gas Analyzer	Class II	1	7
ECG Machine	Class II	13	117
Ultrasound Machine	Class II	7	33
CT scanners	Class II	1	8
MRI ma-chines	Class II	0	4
ICU Beds	Class I/II	0	19
Oxygen Concentrator	Class II	2	90
Patient Mon-itor	Class II	50	816
X-Ray	Class II	13	57

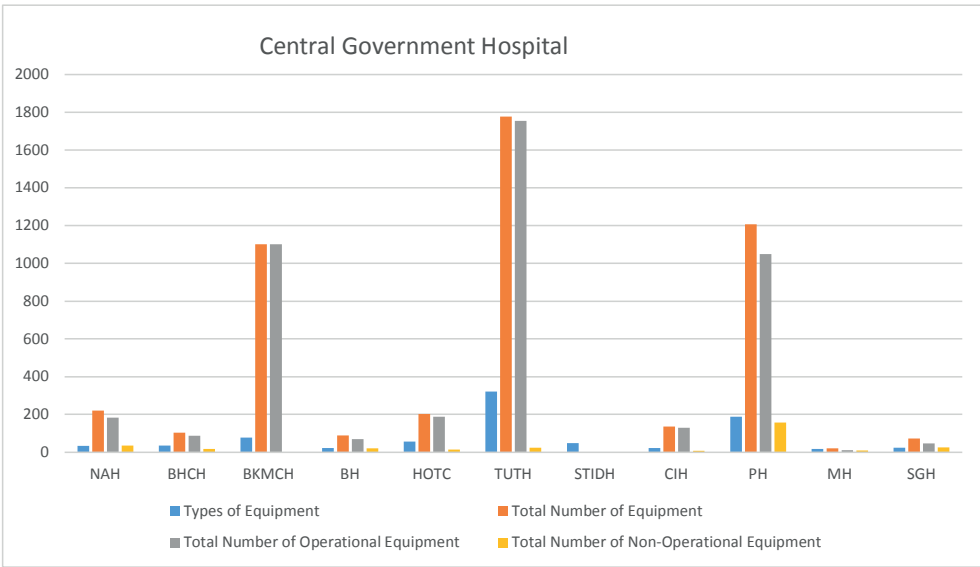

Figure 1 Hospitals under the Central Government

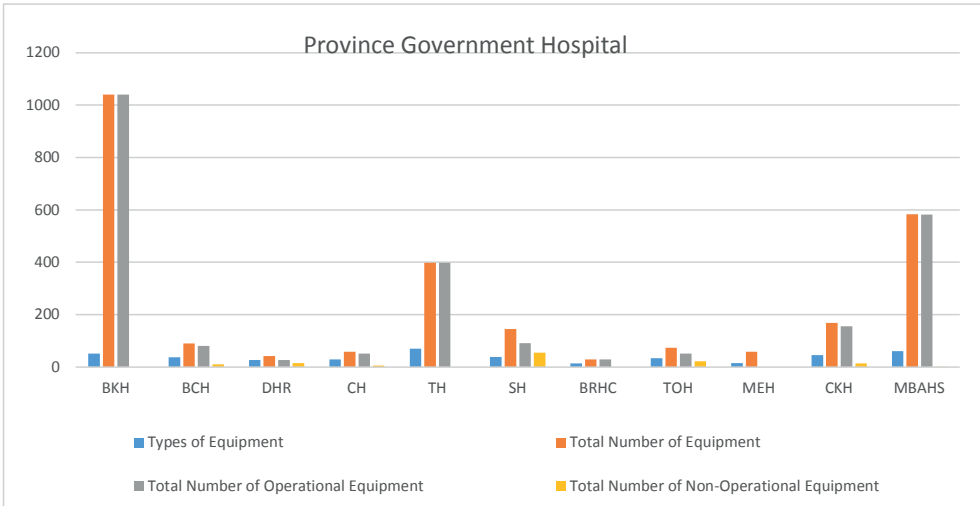

Figure 2 Hospitals under the Provincial Government

3. Results and Discussion

Results

Availability of Biomedical Equipment

In the Bagmati Province, 22 hospitals had a total of 7594 pieces of biomedical equipment, of which 22 hospitals had 631 different kinds of equipment. Regarding the total number of equipment, the TUTH has the highest number of biomedical equipment, with 1778, while MH has the lowest, with only 20. However, no data was provided by the STIDH in the digital health portal of the BEMS at https://bems.mohp.gov.np/ (Table 2 Figure 1).

Prevalence of operational and non-operational equipment in the hospital of Bagmati Province

Operational and non-operational equipment was surveyed in hospital data, totalling 7134 units. TUTH, TH, BKH, and BHRC have complete operational biomedical equipment, whereas other hospitals have a prevalence of 55%, and almost all equipment is functioning. Similarly, data presents considerable variation in the prevalence of non-operational biomedical equipment across different hospitals. SH resulted in 37.24%, and CKH resulted in 36.12% of its equipment being non-operational, as illustrated in Table 3. However, neither the STIDH nor the MEH offered any information for the BEMS digital health portal, which can be accessed at https://bems.mohp.gov.np/.

Number of Operational and Non-Operational Critical Care Equipment in Each Hospital

Critical care equipment is crucial for managing essential patients, improving patient outcomes and saving lives. Hospitals have many operational equipment, including patient monitors, ventilators, infusion pumps, electro-cardiogram machine

(ECG machines), and hemodialysis machines. Table 4 presents the operational status of critical care medical equipment across hospitals, categorized by United States Food and Drug Administration (U.S. FDA) classification (Class I, II, and III based on risk level). Among the devices, Class II equipment such as patient monitors (816 operational, 50 non-operational) and ventilators (250 operational, 61 non-operational; Class II/III) show both high usage and significant non-functionality. Class III equipment, like defibrillators, also shows concerning numbers, with 6 units reported as non-operational. As highlighted by data, the functional critical care equipment shortage disrupts routine hospital services, delays emergency responses and increases patient risk, revealing serious maintenance and hospital readiness gaps.

Equipment in Central and provincial hospitals

The information from 22 hospitals in the province of Bagmati became available on the site. Of the 22 hospitals, 11 are under the central government's jurisdiction, while the remaining 11 are under the provincial government. The abovementioned information offers significant insights into the relationship between the quantity and variety of biomedical equipment and the related patient capacity in central and provincial government hospitals.

Figure 1 and Figure 2 illustrate that TUTH leads in terms of equipment variety, with 321 varieties, followed by PH with 189 types. The prevalence of equipment in central government hospitals indicates various equipment types among multiple institutions. These hospitals serve many patients with operational efficiency despite differences in the kinds of equipment. A similar trend of matching equipment types to regional healthcare needs may be seen in the predominance of equipment in provincial government hospitals. Compared to BKH and MBAHS, which have 52 and 60 equipment kinds, respectively, and TH, which has 322 equipment types, it may be assumed that TH has a more extensive patient capacity.

Hospitals' biomedical equipment diversity and volume have an advantageous impact on patient capacity. Com-prehensive facilities play a strategic role in healthcare since they can handle higher patient numbers better than hospitals with limited equipment types. However, despite having fewer equipment types, Mental Hospitals (MH) exhibit excellent service delivery and operational efficiency. Therefore, hospital categorization shouldn't be based exclusively on equipment diversity.

Discussion

The assessment and management of biomedical equipment in government hospitals in Bagmati Province, Nepal, highlight the significant impact of healthcare infrastructure on patient care quality. The need for robust bio-medical equipment management systems has become more apparent against Nepal's evolving healthcare policies, such as the National Health Policy of 1991 and the 2015 Constitution, which promoted decentralisation and regionalisation.(Government of Nepal, 2015; His Majesty Government of Nepal, 2000). While existing systems like the Health

Management Information System (HMIS), Logistic Management Information System (LMIS), and Human Resource Information System (HuRIS) have enhanced various aspects of healthcare management, they lack a dedicated focus on biomedical equipment.(Government of Nepal, n.d.; Population, 2019). This gap un-derscores the critical importance of the newly implemented BEMS, which aims to address the challenges of equipment maintenance, utilisation, and management across healthcare facilities.

Biomedical equipment management is vital in providing high-quality healthcare services, protecting patients and healthcare personnel, and ensuring that systems are used safely, correctly, and effectively in patient care. The incidence of biomedical equipment and the functioning quality of medical equipment in federal and provincial government hospitals in Bagmati Province, Nepal, are assessed in this study. We discovered that the operational status of several types of equipment revealed the wide range of medical technology accessible in the region. 94.34% of the equipment at public hospitals in Bagmati Province was operational & with less non-functioning equipment.

The distribution of equipment counts is consistent among the hospitals investigated. Autoclaves, biochemistry analysers, ECG machines, electrolyte analysers, hot air ovens, ventilators, oxygen concentrators, X-ray machines, patient monitors, microscopes, OT lights, defibrillators, ultrasound machines, nebulisers, pulse oximeters, suction machines, syringe pumps, electrosurgical machines, and incubators are the most common types of equipment found in all hospitals.

During our investigation, we discovered that a scarcity of trained human resources (BME/BMET) to manage biomedical engineering devices at health institutions impedes real-time data collection. It is found that equipment handled besides BME/BMET leads to inadequate maintenance, poor recording, and reporting. This might lead to increased costs, administrative burdens, and a reduced quality of care. A study conducted in rural government hospitals discovered that the number of non-functional devices in hospitals without BMETs was twice that of hospitals with BMETs(Thapa et al., 2022). Multiple suppliers in the region suggest that hospitals in Bagmati Province have access to various equipment options. Previous research on hospital equipment maintenance in Nepal identifies challenges with imported biomedical equipment and a shortage of competent technical special-ists.(Karna & Jain, 2023).

The Government of Nepal has made progress in standardising biomedical equipment through the Technical Specification Bank (TSB), which supports procurement and inventory management by categorising equipment based on medical specialities.(DoHS, 2017). However, there is no formal adoption of a risk-based classification system like the U.S. FDA's Class I, II, and III model. This lack of risk-based categorisation limits systematic assessment of equipment safety and regulatory prioritisation, which is essential for effective biomedical equipment management.

The investigations based on hospitals solely focus on the results of the equipment

and aid in the analysis of people's diseases.(M. of H. and P. N. Government of Nepal, 2022). The government study focuses on the minimal service criteria, but in circumstances such as pandemics, the study lags behind the facts needed for the next plan.(MOHP Nepal, 2019). According to the research, the data shows that many critical care machines in hospitals are not working, which disrupts daily services and delays emergency treatment, putting patients at greater risk. This issue is mainly due to poor maintenance, insufficiently trained technicians, slow repairs, and weak infra-structure. Our research focuses solely on healthcare equipment reports: functionality, year, serial number, manufacture, human resources in health facilities, etc., which provides a broad spectrum of health technologies in health facilities, which could aid in day-to-day function, improve patient care, emergency preparedness, post-pandemic scenarios and future planning.

Limitation

The study has several limitations due to the availability of biomedical equipment in Nepal. It was carried out in the Bagmati Province; hence, it might not apply to other areas. The study also discovered that many hospitals did not update their data daily, which would have impacted the reliability of the findings. The present state of the equipment in some hospitals may not be reflected on the Biomedical Equipment Status site. Only 22 out of 29 hospitals provided data, which may have impacted sample size and validity. Each hospital's inventory lacked comprehensive data for every metric, which could have affected the accuracy and completeness of the results. Data upkeep varied among hospitals, with some maintaining more thorough records than others. Data access was complicated in some hospitals because of additional ethical approval committees. The BEMS site is presently under beta testing and only has a few equipment-specific parameters. Further research on biomedical equipment is needed in Nepal's central, provincial, and local government hospitals, with a focus on the quality of care provided, public health, equity in healthcare services, regulatory framework, public-private partnership, in-ter-disciplinary collaboration, biomedical engineering, annual maintenance contract (AMC) and comprehensive maintenance contract (CMC), and standard operating procedures (SOPs) for equipment use, sensitivity analysis and optimization, validation, and commissioning.

4. Conclusion

Biomedical equipment, encompassing devices such as diagnostic imaging machines, ventilators, and patient monitors, is crucial for modern healthcare delivery. Biomedical equipment is vital in contemporary healthcare, particularly in the 21st century. Hospitals should focus on inventory and service delivery, ensuring they have the resources to deploy the required technology and medical equipment. It has been found that there have been several challenges: performance and lifespan of biomedical equipment; use of available biomedical equipment; shortage of human resources; distribution where it is most needed; regular calibration and testing of equipment;

and regular training sessions and workshops for efficient operational efficiency, safety, and patient care quality. The study evaluates the effectiveness of collecting real-time data on biomedical devices in government hospitals through the BEMS. The findings aid in planning effective maintenance and replacement of these devices and utilising the annual maintenance AMC and CMC equipment within and beyond the contract. The data collected also informs policy decisions in Nepal regarding the procurement and third-party calibration of biomedical equipment, establishes SOPs for equipment use, maintenance, and safety and guides the development of regu-lations to ensure the availability and quality of biomedical equipment in the country.

Author Contributions:

Conceptualization: Nabin Narayan Munankarmi, Meghnath Dhimal, Pradip Gyanwali, Eak Dev Khanal, Meth-odology: Nabin Narayan Munankarmi, Sudarshan Sharma, Software: Bikash Gurung, Validation: Nabin Narayan Munankarmi, Sudarshan Sharma, Dikshya Chhetri, Formal Analysis: Raymond B.C, Investigation: Eak Dev Khanal, Resources: Dikshya Chhetri, Data Curation: Raymond B.C., Writing – Original Draft: Raymond B.C, Writing – Review & Editing: Meghnath Dhimal, Pradip Gyanwali, Eak Dev Khanal, Nabin Narayan Munankarmi, Visualization: Bikash Gurung, Supervision: Raymond B.C, Project Administration: Nabin Narayan Munankarmi, Funding Acquisition: Nabin Narayan Munakarmi

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