THE EVALUATION OF ALTERNATIVE CARE PATHWAYS FOR THE MANAGEMENT OF NON-COMMUNICABLE DISEASES AT TERTIARY CARE HOSPITAL DURING THE SITUATION OF COVID-19 PANDEMIC

BY

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ENTITLED

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ABSTRACT

Background: The management of non-communicable diseases (NCDs), such as hypertension (HT) and diabetes mellitus (DM), were significantly impacted by the COVID-19 pandemic as many institutions adopted alternative care pathways, e.g., pharmacy at home (PAH), and the deferred care (DC) programs. While some studies have assessed the clinical outcomes of PAH program, there is a paucity of evaluative work dealing with the clinical and economic impacts of DC programs. Consequently, this study evaluates the clinical and economic outcomes of the adoption of PAH and DC programs as alternatives to usual care.

Method: A retrospective study was conducted at a tertiary care hospital in Thailand concerning the management of HT and DM patients during July 2021 to December 2021 and following July 2022 to December 2022. Administrative and

clinical data were drawn from outpatient encounters according to three management options: PAH; DC; or discharged home with follow-up at the hospital. Multivariate multilevel mixed-effects linear and log-linear regression methods were used to assess the impact of care pathways on clinical and economic outcomes, respectively.

Results: There were 3,518 patients during the pandemic and 4,135 patients following the pandemic that were included in this study. There was no statistically significant impact of the PAH and DC on the changes of systolic blood pressure, diastolic blood pressure, and fasting blood sugar, but the PAH and DC did have a significant impact on the cost of illness in both periods significantly ($p < 0.001$).

Conclusions: The used of PAH and DC programs reduced costs but did not worsen clinical outcomes for DM and HT patients during and following the pandemic. These programs are appropriate for regular use and may be further reactivated in the event of future emergencies.

Keywords: COVID-19; care pathway; telehealth; NCDs; diabetes; hypertension

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CHAPTER 1
INTRODUCTION

1.1 Background and research rationale

According to the WHO, noncommunicable diseases (NCDs) accounted for up to 71% of all deaths worldwide in the year 2022, the majority of which occurred in low- and middle-income countries (1). This is consistent with data from Thailand that NCDs are accounted for 75% of all deaths between 2014 and 2018 (2). The four leading causes of death from NCDs worldwide are cardiovascular diseases, cancers, chronic respiratory diseases, and diabetes (1,2). Thus, many policies in accordance with WHO recommendations, have been developed globally to prevent, control, and reduce mortality from NCDs. Individuals with NCDs were affected by the COVID-19 outbreak because they are required on-going treatment (3). Healthcare service availability was diminished globally due to widespread service disruptions during the COVID-19 outbreak. Service disruptions were either partial or complete. These resulted in a reduction of healthcare visits, hospital admissions, diagnostic, and treatments (3-8). Services for hypertension, asthma, diabetes, and cancer were likely to be extensively disrupted among most WHO member countries in the year 2020 (7). The limited availability of healthcare services during the COVID-19 outbreak adversely affected the treatment outcomes of individuals with NCDs, as noted in the database review between 2020 and 2021 (5,9,10) . Furthermore, there were other factors associated with the COVID-19 pandemic that could contribute to unfavorable outcomes, including restriction on physical activity, dietary limitations, and avoidance of community interactions (5,9,10).

The COVID-19 outbreak has changed clinical practices and patients' behavior with respect to NCDs (3-11). Various policies have been adopted by countries to control the spread of COVID-19 and maintain healthcare services up to present (5-7,12-14). Many large hospitals in Thailand implemented an array of policies in the face of the pandemic, such as the use of telehealth along with pharmacy at home programs, and telehealth along with deferred care programs (7). To our knowledge, there were

only a few studies that have evaluated the clinical outcomes of these policies implemented in hospitals in Thailand (15,16). There were several types of telehealth interventions globally (17-19). Telehealth interventions and pharmacy at home programs were found to offer effective treatment outcomes (20-24). Treatment outcomes in previous studies showed attainment of laboratory results in alignment with therapeutic goals, improved medication adherence and reduction in hospitalization (16,20-23,25-27). Deferred care was an effective program (25,26,28). This program was recommended based on the characteristics and severity of the disease (28). Regarding to the literature searched from several international databases such as the PubMed, the ScienceDirect, the Scopus, and the EBSCO using relevant search terms, there is an absence of studies dealing with the evaluation of telehealth in conjunction with pharmacy at home programs, as well as telehealth along with deferred care programs for the management of NCD patients.

To date, telehealth interventions and pharmacy at home programs have been evaluated separately for economic outcomes (29). However, the evaluation of economic outcomes for the deferred care programs has not been evaluated. Telehealth interventions have shown benefits in reducing the cost of healthcare services and the out of pocket costs for patients (29). There were only two studies that evaluated economic outcomes of pharmacy at home programs in Thailand before the COVID-19 outbreak. The total costs per one physical mailbox was 43 THB from the provider perspective in the year 2003 (30). The total costs were composed of direct cost of labor and material. The labor costs were 18 THB per one mailbox (calculate only pharmacy department). The material costs were 9 THB for packaging and 16 THB for postal fees per one mailbox. Furthermore, the cost-effectiveness analysis (CEA) of the pharmacy at home program in Thailand relative to the schizophrenic patients at Suanprung hospital between 2009 and 2010 from the societal perspective was analyzed. The study found that after seeing a physician, and patients received pharmacy at home program, the total cost was approximately half that for patients who received drugs in person (12,765 THB versus 24,028 THB). The total costs were composed of direct medical costs, direct non-medical costs, and indirect costs. Patients enrolled in the pharmacy at home program incurred direct non-medical costs, and indirect costs only during their first time of medicine receiving. Furthermore, patients who received pharmacy at home

had a higher probability of continuing to receive prescribed medication without recurring symptoms than patients who received drugs at the outpatient department (0.57 and 0.51, respectively). The incremental Cost-Effectiveness Ratio (ICER) was calculated by dividing the difference in total costs by the difference in probability of continuing to receive prescribed medication without recurring symptoms. The study found the ICER was -187,713.67 THB per one patient who continued to receive prescribed medication with no recurring symptoms (31). To gain one more patient in the pharmacy at home program who continued to receive prescribed medication without recurring symptoms could save 187,713.67 THB compared to the patient who received drugs at the outpatient department (31).

The telehealth along with pharmacy at home and the telehealth along with deferred care programs are the COVID-19 policies that are widely adopted at tertiary care hospitals in Thailand. There were a few studies that assessed the clinical and economic outcomes associated with those COVID-19 policies on patients with NCDs in Thailand. The healthcare services have been transformed into various care pathways during the COVID-19 outbreak to reduce viral transmission and maintain continuity of care. Therefore, this study evaluated the care pathways including the telehealth along with a deferred care program (DC), the telehealth along with a pharmacy at home program (PAH), and DC+PAH provision under COVID-19 policies for NCDs both clinical and economic outcomes. Findings from this study help inform policy decision making by advancing recommendations for enactment of policy revisions for the Ministry of Public Health (MoPH). If telehealth along with pharmacy at home, and deferred care programs can deliver economic and clinical outcomes that are comparable to standard care, the MoPH evidence-informed decisions may be undertaken during the post-pandemic period. However, if these policies result in increased costs or poorer clinical outcomes for patients compare to standard care, it is hoped that such policies would be curtailed. In addition, this study also demonstrates the most effective care pathway (DC, PAH, and DC+PAH) in terms of clinical and economic outcomes for the MoPH to consider. If telehealth along with pharmacy at home, and deferred care programs, could be utilized during the post-pandemic period, they may result in several benefits:

Healthcare system: Policies advance the healthcare system by improving service delivery and enhancing patient access to healthcare services.

Patients: There reduces in waiting times and alleviates of overcrowding in hospitals.

Healthcare providers: This allows more time to devote to patients with severe symptoms and provides greater opportunities to manage them effectively.

1.2 Research questions

How have clinical and economic outcomes changed because of the implementation of policies during the COVID-19 pandemic?

How should care pathways for NCD patients be implemented in tertiary care hospital?

1.3 Objectives

1.3.1 General objectives

To evaluate the provision of care pathways on clinical and economic outcomes under COVID-19 policies for NCDs.

To develop a policy brief of NCDs care in tertiary care hospital in terms of service transformation for the post-pandemic period.

1.3.2 Specific objectives

To study clinical outcomes on missed appointments, failure to receive drugs, surrogate markers, and hospitalizations in each care pathway under COVID-19 policies for NCDs.

To study economic outcomes on cost of illness, and cost of health service in each care pathway under COVID-19 policies for NCDs.

To compare clinical and economic outcomes among the various care pathways under COVID-19 policies for NCDs.

1.4 Hypotheses

H_o = There is no difference in clinical and economic outcomes among various care pathways.

H_a = There is a difference in clinical and economic outcomes among various care pathways

CHAPTER 2
REVIEW OF LITERATURE

2.1 COVID-19 Policies

Many policies have been implemented globally in response to the COVID-19 outbreak (6,7,12-14,32). The policies included school and workplace closures, cancellation of public events and gatherings, stay-at-home restrictions, face coverings, public information campaigns on COVID-19, international and domestic travel control, testing for COVID-19, and vaccination. These global policies were consistent with the policies in Thailand, including travel control, mask wearing, hand washing, and social distancing (7). Thailand's Center for COVID-19 Situation Administration (CCSA) had advised the public to take DMHTT precautions to prevent the spread of COVID-19 : D-distancing, M-mask wearing, H-hand washing, T-temperature check, and T Thai chana contract tracing application. These policies were implemented at the country-level. In Thailand, hospital-level policies have been developed since the COVID-19 pandemic began. There was only one study in Thailand that explores COVID-19 policy implementation. The summarization of COVID-19 policies from seven large hospitals (+ 200 beds) in Thailand is shown in Table 2.1 (7).

2.1.1 The telehealth along with deferred care programs (DC)

DC programs represented the postponed of treatment. Five out of seven large hospitals implemented the DC program. Non-emergency patients, including NCD patients, psychotic patients with stable symptoms, and elective surgery patients received the DC program during COVID-19 outbreak.

2.1.2 Service shutdown program

Service shutdown program occurred substantially for rehabilitation services. Most of the special medication clinics (SMC), Thai traditional medicine services, home visit services, and health promotion and disease prevention services

were closed in Thailand. All seven tertiary care hospitals have implemented a service shutdown program.

2.1.3 Addition and replacement

Addition and replacement services were implemented in all seven hospitals. Services included telehealth along with pharmacy at home, medication refill at Sub-district Health Promoting Hospitals, patient referrals to primary care services, and hospital queue management via mobile devices.

2.1.4 Service adjustment

Service adjustment represented a change of service procedures including patient visiting restrictions, COVID-19 screening procedures and hospital capacities in terms of hospital beds and staffing.

NCD patients required on-going treatment. The study mentioned above (7,33) showed that the standards of care was replaced by DC and PAH. Those policies have been widely applied in seven large hospitals in Thailand. The postponement of appointments within the DC program required approval from both the healthcare provider and the patient. The inclusion criteria were patient with stable symptoms and sufficient medicine at home. The procedures of telehealth along with pharmacy at home program are as follows.

Public relations

The hospital promoted the program through many channels, including facebook page, website, and information given by healthcare personnel. Patient symptoms were evaluated by the doctor before the patient got the pharmacy at home program.

Patients' selection criteria for pharmacy at home program

In all hospitals, those patients who required continuous care and had controlled symptoms were the priority for this program. Liquid drugs, injectable drugs, refrigerable drugs, and chemotherapy drugs were not eligible to be delivered by mail. Approval to enter this program required by physician and patient consent.

Evaluation and prescribing by a doctor

Telehealth along with a pharmacy at home program could be requested by either a patient or health personal. Telehealth along with pharmacy at home program was commonly requested by the patients over the phone. The nurse compiled a list of patients who were approved within 1–7 days. The nurse made a phone call for enrollment. The medical histories of the patient enrolled were sent to the doctors. Laboratory testing was necessary for some patients. The patients could obtain their laboratory test at the most convenient medical facility. The pharmacy at home program was started after medication history and laboratory tests were assessed by the doctor. The exclusion criteria were patients with unstable symptoms who were required to see a doctor at the hospital.

Delivery of medicines to patients

The staff in the examination room or the pharmacy room contacted the patient by phone to confirm the pharmacy at home program and patient's address those were listed by the nurse. The patient list was forwarded to the pharmacy department for drug delivery. The medication was delivered via Thailand post. The patient was responsible for the fixed-rate (100 THB) delivery fee or a fee based on the weight of the delivered package and the distance mailed. Pharmacist at the designated hospital was responsible for reviewing the medication list, preparing medicines, and contacting patients for medication consultations.

The telehealth along with deferred care and telehealth along with pharmacy at home program were the COVID-19 policies that were widely used by NCD patients at large hospitals in Thailand. Therefore, this study focused on NCD patients who received those two programs. Since the implementation process of those two programs was quite similar among tertiary care hospitals in Thailand, only one hospital was included in this study.

2.2 Evaluation healthcare service for NCD patients

The policies implemented during the COVID-19 outbreak could be categorized into National-level and hospital-level policies. National-level policies referred to the measures and guidelines set by the government at the national level to address the overall management and control of the pandemic. These policies might

include border controls, travel restrictions, lockdown measures, public health campaigns, testing strategies, contact tracing efforts, vaccination programs, and resource allocation. Hospital-level policies focused on the specific guidelines and protocols implemented within healthcare facilities to ensure the safety and effective management of COVID-19 and non-COVID-19 patients. These policies might involve infection prevention and control measures, triaging and screening protocols, isolation procedures, treatment guidelines, resource management, and staff training (6,7,12-14,32).

NCD patients were impacted from COVID-19 and COVID-19 policies. Direct pressures included drug shortages, delays, and cancellations of appointment and elective procedures. Indirect pressures included reduced physical activity from limited access to the gyms or exercise equipment, dietary shifting to unhealthy food choice, alcoholism, and illicit drug abuse (3). WHO surveyed healthcare services for NCD patients in the European region in the year 2020. Thirty-nine countries reported that 69% of inpatient services and 77% of outpatient services were disrupted. Normal operations of outpatient and inpatient services were reported in only six out of thirty-nine countries (11). To identify the causes of disruption, a survey was conducted by the WHO across 122 countries. The causes of disruption were identified as follows: 75% reported elective care cancellations, 46% reported the closure of population screening programs, and 43% reported government or public transport lockdowns that hindered access to health facilities. It could be observed that the majority of disruptions arose from healthcare providers, while only 25% of disruptions were caused by patients trying to avoid a healthcare encounter due to the COVID-19 outbreak (11). The utilization of healthcare services, including visits, hospitalizations, diagnostics, treatments, disease prevention and health promotion were decreased by 30-50%, especially during the lockdown period (3,5-7).

The clinical outcome of NCDs was indicated by surrogate and final outcomes. The surrogate outcome was a biomarker which was a valid predictor of the outcome. The surrogate outcomes included laboratory test, adherence, and drug related problems (DRPs). The final outcomes could be assessed by mortality rate, admission to hospital, and comorbidity. The surrogate outcomes were assessed in various studies related to NCDs during the COVID-19 outbreak, such as glycated hemoglobin

(HBA1C), fasting blood sugar (FBS), and physical examination (34-36). The surrogate outcomes during the COVID-19 outbreak were compared to before the COVID-19 outbreak. Those studies found worse surrogate outcomes during COVID-19 outbreak. The mortality rate was measured as the outcome in the previous study. The mortality rates in the United States and 43 international countries were increased after the implementation of movement restriction policy in the year 2020 compared to the average mortality rate during the years 2015-2019 (14). Another study assessed final outcomes (7), including inpatient mortality rate from all causes, re-hospitalization within 30 days, and length of stay (LOS) during the COVID-19 outbreak. The data were obtained from the National Health Security Office (NHSO) and five hospitals databases in Thailand. The incidence rate ratio (IRR) and odd ratio (OR) from multivariate regression analysis on the clinical outcome during the COVID-19 outbreak compared to during the years 2016-2019 were estimated. The results of those outcomes were varied between the data from NHSO and hospitals databases.

The studies mentioned above predicted the clinical outcomes regarding to the COVID-19 policies at the national level including lockdown, shelter in place (SIP), and hygiene policies (7,14,34-37).Various strategies were used at the hospital-level for continuing care especially for the NCD patients. Telehealth deployment to replace in-person consultation was the most effective alternative strategy (81%), followed by triaging to identify priorities leading to deferred care (72%), task shifting or role delegation (44%), redirecting patient with NCDs to alternate health facilities (38%), and novel supply chain and/or dispensing approaches for NCD medicines (31%) (11). Telehealth and deferred care were the strategies that were most highly used during the COVID-19 outbreak as the reports of WHO member countries including Thailand (7,11).

2.2.1 Telehealth

Telehealth was an umbrella term that covers telemedicine, education and training (38). Telehealth, also known as telemedicine, referred to non-person-to-person methods of communication, such as the telephone and digital media (11). Several terminologies were used to define telehealth, such as remote consultation, virtual consultation, distant medicine, e-Health, and digital technologies, as well as

cybermedicine and telemedis (18). Telehealth products could be defined as any tool, appliance, software, or similar application that the producer intends to be used alone or in combination for the purposes of diagnosis, prevention, monitoring, or treatment (17,39). The systematic review of telehealth intervention in chronic disease patients during the COVID-19 outbreak summarized the usages into six domains: medication, communication, follow-up, training, consultation, and caregiver support (19). Telehealth intervention has been used before the COVID-19 outbreak. A systematic review of 34 studies (20) summarized the clinical outcomes of chronic disease management (hypertension, diabetes, anticoagulation, depression, hyperlipidemia, asthma, heart failure, HIV, post-traumatic stress disorder, chronic kidney disease, stroke, COPD, and smoking cessation). Most of the examined studies (25 studies) focused on telephone-only intervention. Attainment of laboratory results in alignment with therapeutic goals, improved medication adherence, improved physical examination, and reduction in mortality rate were results that improved clinical outcomes of the studies. There were several methods of comparing statistics that could be used, depending on research questions and the type of data being analyzed. The statistical methods included the student t-test, the chi-square test, survival analysis or regression analysis. Telehealth interventions were found to be an effective strategy (17,20-23). Positive improvements in illness management, self-management, or adherence measures were reported in 23 of 34 investigations (20). The systematic review of 10 studies (20) found neutral outcomes (noninferior to the comparison), and only one study found a poor outcome for the telehealth group. Telehealth intervention also had some limitations leading to poor outcomes, including the need for reliable internet access, the lack of physical interaction between patients and healthcare providers, and the potential for technical difficulties (40). Telehealth intervention had become increasingly important to provide healthcare services during the COVID-19 outbreak. Telehealth intervention was a resource for enhancing patient surveillance, preventing the spread of disease, facilitating the timely identification and management of new patients, and ensuring the continuity of care for frail patients (41,42). In Thailand, telehealth intervention had been implemented as hospitals-level policy during the COVID-19 outbreak primarily using telephone-only intervention for medication consultation, communication, and follow-up symptoms (7). There were only few

tertiary care hospitals in Thailand use telehealth intervention via software or applications (7).

Telehealth along with pharmacy at home program was a widely implemented hospital-level policy in Thailand. It was the result of integrating telehealth interventions with the pharmacy at home program. The telehealth along with pharmacy at home program began from telehealth intervention until drugs were sent by postal service to patients. The medications were approved and arranged for shipment by the staff at pharmacy department (7). Postal drug method was an effective method in terms of medication adherence and clinical outcomes from various studies before COVID-19 outbreak (43,44). There was no published study on clinical evaluation of telehealth along with pharmacy at home in international databases. Even though, there was only one study in Thailand comparing telehealth along with pharmacy at home programs during the COVID-19 outbreak and standards of care (16). A paired t-test was a statistical test that was used to compare the mean of two dependent groups. This study found that there was no statistically significant difference in the outcome (average blood pressure levels) before and after receiving the telehealth along with pharmacy at home programs. Furthermore, the patients had a high level of knowledge about drug used (70.8%), adherence (79.3%), and satisfaction (96.2%) after receiving the telehealth along with pharmacy at home programs.

The previous study (29) was reported the use of telehealth intervention and benefits in reducing the cost of healthcare services and patients' out of pocket. Cost of healthcare services included equipment, building, supplies, and wages. Patients' out of pocket include transportations, meals, and accommodations. The systematic review study of cost-effectiveness analysis of telehealth found that telehealth was claimed to be cost effective (45).

2.2.2 Pharmacy at home program

In the United States (US), pharmacy at home program by mail has been started since 1968. It was initially used as special options for veteran administration and American association retired person due to the convenience of receiving medication. The pharmacy at home program gained more popularity after the national health care reformed in 1983, primarily due to cost reduction and convenience.

The program was widely utilized in the US to deliver medications, with up to 1/3 of chronic illness medications being delivered by mail. Patients, especially those with chronic disease, expressed satisfaction with the pharmacy at home program as it ensured continue access their medication. However, despite the advantages of the pharmacy at home program, there were also drawbacks such as potential time delays, medication waste, and limited opportunities for patient-pharmacist interaction. The process of drug preparation began with receiving the patient's requisition, recording the prescription code, reviewing the prescription, documenting patient data, printing labels, refilling medications, verifying drugs, packing them, and finally preparing them for mailing (30). Several articles suggested a positive association between using pharmacy at home program and improved adherence to diabetes and antihypertensive medications, as well as better LDL-C control (43,44). The study conducted in US compared users of the pharmacy at home program and users of local pharmacy program by logistic regression model. The study found that the pharmacy at home program was associated with fewer emergency department visits and hospitalization (27,43). Additionally, the pharmacy at home program was found to be associated with achieving HbA1c level below 8% (27).

In Thailand, pharmacy at home program has been used in psychiatric hospitals for over 20 years to enhance patient convenience and compliance. However, a significant challenge of the pharmacy at home program in Thailand lied in the patient’s monitoring. A study conducted at Khonkhaen Psychiatric Hospital assessed the satisfaction of 200 psychiatric patients who received medication through mail-order service, revealing that 86.5% of patients were satisfied and continued to use this service (30). Suggestions for improvement included the inclusion of drug information inserts, timely communication of changes in drug manufacturers, and the provision of drug information services via mail. At Suanprung Hospital, patients receiving the pharmacy at home program were monitored by doctors near their homes every 6 months to ensure symptom stability before continuing the program. The pharmacy at home program for chronic diseases has been started in Thailand since the year 2003. Under this model, patients visited their doctors, submitted prescriptions to the outpatient pharmacy unit, and then returned home while the pharmacy unit dispatches the medications by mail (30). During the COVID-19 outbreak in Thailand, the pharmacy at home program was

adapted to incorporate telehealth interventions, such as the tele-pharmacy program provided by pharmacists in conjunction with the pharmacy at home program for chronic diseases, as well as telehealth services combined with the pharmacy at home program for diabetes or hypertension patients (15,16,46,47).

2.2.3 Deferred care

Deferred care referred to medication care that has been delayed or postponed (32). This might occur from financial constraints, lack of access to healthcare, and fear or anxiety about seeking medical attention. Deferred care could be particularly concerning for individuals with chronic health conditions, as delayed treatment could lead to a worsening of symptoms and potentially serious health complications. Deferred care due to COVID-19 referred to healthcare services or treatment that have been postponed or delayed as a result of the COVID-19 outbreak (32). Many individuals have deferred care due to concerns about exposure to the virus or limited access to healthcare services. Untreated or undiagnosed, including routine check-ups, procedures, and chronic disease management led to more severe health problems (28,48).

Deferred care was important to prioritize essential medical care to prevent serious health consequences. Prioritization might be based on several factors, including the severity of the condition, the risk of complications, and the potential impact on the patient's overall health (32,48). Healthcare providers might use various tools and guidelines to prioritize deferred care (3). For instance, one example was the guidance offered by the Centers for Disease Control and Prevention (CDC), which outlined strategies for prioritizing healthcare services and included recommendations specifically tailored to non-COVID-related care (49). The CDC has recommended that routine primary and special care, care for well-controlled chronic conditions, routine screening for asymptomatic conditions, elective surgery and procedures might be deferred if necessary. The results of deferred were depended on an individual's condition and the length of time that care is delayed. Continuous deferred care was more likely to result in patient harm. Telehealth intervention was utilized in conjunction with deferred care in hospitals in Thailand. This approach was specifically referred to as "telehealth along with deferred care". The process of the telehealth along with

deferred care was subjected to the approval of both the healthcare provider and the patient. The inclusion criteria were patients with stable symptoms and sufficient medicine at home. There was no study that evaluate clinical and economic outcomes of the deferred care policy in NCD patients. In summary, some types of medical care might be more suitable for deferred care than others. Patients were responsible and should prioritize their healthcare needs to seek necessary medical treatment in a timely manner. If not, deferred care could lead to more serious health conditions and medical costs. Delaying treatment for a chronic condition could result in more expensive emergency room visits or hospitalizations (28).

Individuals with NCDs were affected by COVID-19 and COVID-19 policy. Many policies have been implemented during the COVID-19 outbreak, especially telehealth along with pharmacy at home and telehealth along with deferred care programs. This study primarily concerned clinical and economic outcomes of the two main types of NCDs (HT and DM) from those policies. The two main types of NCDs were focused because of the high-rate disruption and the extensive implementation of policies. The clinical outcomes included both surrogate and final outcomes. The surrogate outcomes were the missed appointment, failure to receive drug, and surrogate markers. The final outcome was the hospitalization. If these policies were effectively implemented, patients who met the criteria established in this study would not experience missed appointments, failure to receive drug, abnormal test results, and hospitalization. The hospitalization could be early intervention for the management of abnormalities, visits to the emergency room, and hospitalizations due to disease or complications. Cost of illness and cost of healthcare service had not been evaluated in telehealth along with pharmacy at home and deferred care programs. Therefore, cost of illness from the societal perspective, and cost of healthcare service from the provider perspective were estimated concurrently to examine economic outcomes. If these policies were implemented successfully, the cost of illness should not be increased. Those clinical and economic outcomes were collected from the hospital database in each care pathway such as the telehealth along with deferred care program (DC), the telehealth along with pharmacy at home program (PAH), and all other mutually exclusive and exhaustive other care pathways to predict and extrapolate the results in the nationwide. Regression analysis was employed in this study.

Moreover, multilevel model was used adjunct to regular regression due to nested data in clinical outcome (50-52). This analysis was a statistical method that estimates the effect on an outcome of interest of an intervention while all potential confounding factors are controlled (53). Continuous data (surrogate markers and cost of illness) was estimated by multilevel mixed effects generalized linear models. The discreate data (the missed appointment, failure to receive drug, hospitalization, and normal-range surrogate marker) were estimated by multilevel mixed-effects logistic regression model (54,55)

2.3 Clinical and economic outcomes attributable by deferred care and telehealth along with pharmacy at home programs during the COVID-19 outbreak.

Clinical and economic outcomes included inpatient mortality rate from all causes, 30-day hospital re-admissions, LOS, ICU admissions, cost of illness, and cost of health service. Many studies examined potential confounding factors affecting the clinical outcomes such as mortality, ICU admission, or hospitalization only COVID-19 patients. There was no published study assessed the impact of potential confounding factors on economic outcomes. There were few studies that assessed the impact of potential confounding factors on clinical outcomes in COVID-19 and non-COVID-19 patients. The studies that evaluated the impact on deferred care and telehealth program implementation were also reviewed.

The simulation study demonstrated that the purposeful selection algorithm identified and retained confounders correctly at a larger rate than other selection procedures, particularly in instances where the significance level of a confounder was between 0.1 and 0.15 (56). Therefore, this study used the cut-off significance level for identification of the main effect of potential confounding factors at p-values ≤ 0.15. Table 2.2 shows the characteristics of the studies assessing the impact of potential confounding factors on clinical outcomes, deferred care and telehealth program implementation during the COVID-19 outbreak. The mortality rate in a large London teaching hospital was collected in the first study (57). The first study compared the mortality rate in a 6-week period during the COVID-19 outbreak commencing with the first report of COVID-19 mortality was on March 12, 2020, to the same period in 2019.

The regression analysis was undertaken to establish the independent effects of ethnicity, sex, and comorbidities. The confounding factors with p-values ≤ 0.15 are shown in Table 2.3. Two and three comorbidities were the confounding factors with p-value ≤ 0.15 in the first study. The mortality rate for COVID-19 and non-COVID-19 patients with two comorbidities in the year 2020 were 1.75 and 2.3 times compared to the patients in the year 2019, respectively. The mortality rate for COVID-19 and non-COVID-19 patients with three comorbidities in the year 2020 were 3.08 and 6.46 times compared to the patients in the year 2019, respectively.

The second study (58) was a retrospective cohort study. The study used data from a large database linking detailed primary care records and mortality registrations for 40% of the population in England. Follow-up time in all adults (aged ≥18 years) for mortality was from February 1, 2020, until November 9, 2020. There were 17,456,515 patients included in the study. There were 17,063 patients died from COVID-19 and 134,316 patients died from other causes. The regression analysis was used to evaluate. Most factors associated with COVID-19 mortality were similarly associated with non-COVID-19 mortality, but the magnitudes of association were different. Older age (>60 year), male, deprivation, obesity, smoking and some comorbidities (diabetes (DM), cancer (CA), hematological malignancy, renal disease, asthma, chronic respiratory disease, chronic cardiac disease, hypertension (HT), chronic liver disease, dementia, stroke, other neurological, organ transplant, asplenia, rheum arthritis/lupus/psoriasis, and other immunosuppression) were the confounding factors with p-value ≤ 0.15 that were associated with the mortality rate both COVID-19 and non-COVID-19 patients. The mortality rate was depended on the patient's health status and severity of comorbidity.

The third study (59) examined patients who were referred to the Vascular Surgery Department of Hubs between March 9, 2020 and April 28, 2020. There were 305 patients collected prospectively and analyzed by regression analysis. COVID-19 and emergency setting were the confounding factors with p-value ≤ 0.15 that were associated with the risk of hospital mortality.

The fourth study (60) was a multicenter retrospective study of trauma patients in Southern California. The factors affecting ICU admission between March 19, 2019, and June 30, 2019 (pre-COVID-19) were compared to the same period in the

year 2020 (COVID-19 outbreak). On regression analysis, presenting respiratory rate >22 breaths/minute and age ≥ 65 years old (Table 2.4) affected in increasing the risk of ICU admission by 49% and 69%, respectively. The COVID period affected in decreasing the risk of ICU admission by 18%.

The fifth study (8) was the cross-sectional study. The Irish Longitudinal Study on Ageing (TILDA) was a nationally representative cohort study of community-dwelling adults aged 50 years and over in Ireland. TILDA participants were invited to participate in the study. Self-completion questionnaire (SCQ) was posted to current TILDA participants in July 2020 and returned surveys accepted until November 2020. A total of 5,535 questionnaires were posted out to participants, with 3,922 participants responding. The final analytic sample included 3,001 participants. Deferred care program implementation was significantly correlated with having two or more chronic diseases, being female, having a high level of education, living in a capital city, living alone, drinking alcohol, non-medical insurance, using several medications, and having one or more general practitioner (GP) appointments (Table 2.5).

The sixth study (61) was a cross-sectional study by the 2020 National Center for Health Statistics, National Health Interview Survey. Individuals (17,586) who responded to delayed and forgone care questions were included. The database was civilian noninstitutionalized individuals within 50 states and the District of Columbia of the United States. Total of 31,568 samples of adults, inclusion of only those who responded to the questions about delayed or forgone care yielded a sample of 17,586 for analysis. This study further restricted the sample (n = 6,390) to those who reported telehealth use related to the COVID-19 outbreak. Factors influencing delayed, forgone care, and virtual care due to the COVID-19 outbreak were investigated by regression analysis. Older age (45-64 years), being male, having medical insurance, high level of education, living in central metro, unemployment, obesity, and some comorbidity including COVID, DM, HT, chronic obstructive pulmonary disease (COPD), CA, arthritis, asthma, anxiety (Table 2.5) were associated with deferred care program implementation. Younger age (18-24 years), living in a large central metro, non-medical insurance, high level of education, and some comorbidity including COVID, DM, CA, arthritis, and anxiety (Table 2.6) were associated with telehealth program implementation.

Factors affecting mortality rate, ICU admission, deferred care and telehealth program implementation during the COVID-19 outbreak that were presented, were used as a covariate in this study. These factors could be categorized into 2 characteristics:

1. Demographic characteristics: age, sex, smoking, drinking, obesity, education, living status, place of residence, medical insurance, multiple visits, polypharmacy, employment status

2. Clinical characteristics: the number of comorbid conditions, DM, CA, renal disease, respiratory disease, chronic cardiac disease, HT, chronic liver disease, dementia, stroke, other neurological, organ transplant, asplenia, rheum arthritis/lupus/psoriasis, other immunosuppression, arthritis, anxiety, COVID-19, and emergency room (ER) visit

Table 2. 1 COVID-19 policies from seven large hospitals in Thailand

Policies	**Hospitals**						
	A	B	C	D	E	F	G
1. Deferred care programs	/		/	/	/	/	
2. Service shutdown programs	/	/	/	/	/	/	/
3. Addition and replacement services							
- Telehealth along with pharmacy at home		/	/	/	/	/	/
- Medication refill	/					/	
- Hospital queue number on mobile device		/		/			
- referring patient to primary care		/	/	/	/	/	/
4. Services adjustment							
- Visiting restriction	/		/	/			/
- COVID-19 screening procedures	/	/	/	/	/	/	/
- Hospital capacities in terms of hospital beds and staffing.	/	/	/	/	/	/	/

Table 2. 2 Characteristics of included studies

Author	Journal	Year	Study place	Number of participants	Participant characteristics		Comparators
					Age	Sex	
Perkin MR (57)	BMJ Open	2020	England	**6 weeks commencing March 12, 2020** -Mortality in hospital from COVID-19 patients = 243 -Mortality in hospital from non-COVID-19 patients = 136 **6 weeks commencing March 12, 2019** -All mortality in hospital = 194	76 76 78	M (67%) M (53%) M (50%)	Factors affecting all mortality in the year 2019 compared to the mortality of non-covid-19 and covid-19 patients in the year 2020
Bhaskaran K (58)	The lancet region health Europe	2021	England	All patients = 17,456,515			Factors affecting mortality of COVID-19 and

Table 2. 2 Characteristics of included studies (Cont.)

Author	Journal	Year	Study place	Number of participants	Participant characteristics		Comparators
					Age	Sex	
Bhaskaran K (58)	The lancet region health Europe	2021	England	-Mortality rate in COVID-19 patient = 17,063 -Mortality rate in non-COVID-19 patient = 134,316	-	M (55.36%) M (49.54%)	non-COVID-19 patients compared to all patients in the year 2020
Kahlberg A (59)	European Journal of Vascular and Endovascular Surgery	2021	Italy	305 patients	72.90	M (73.45%)	Factors affecting mortality in vascular surgery patients
Yeates EO (60)	The American journal of surgery	2022	USA	**March 19, 2019 and June 30, 2019 (pre-COVID-19)** -Patients = 6,942 **March 19, 2020 and June 30, 2020 (COVID-19)**	48.3	M (60%)	Factors affecting ICU admission in blunt trauma patients (BTPs) between pre-COVID-19 and COVID-19 outbreak

Table 2. 2 Characteristics of included studies (Cont.)

Author	Journal	Year	Study place	Number of participants	Participant characteristics		Comparators
					Age	Sex	
				-Patients = 5,802		M (60.3%)	
Hennelly N(8)	HRB Open research	2021	Ireland	3,001 participants -With deferred care = 949 -Without deferred care = 2,052	-	M (43.1%)	Factors affecting deferred care implementation during the COVID-19 outbreak
Lee J (61)	TELEMEDICINE and e-HEALTH	2022	USA	17,586 participants -With deferred care = 4,175 -Virtual care = 6,390 participants	-	M (38.25%)	Factors affecting deferred care and virtual care implementation during the COVID-19 outbreak

Table 2. 3 The impact of potential confounding factors on mortality

Factors	**Studies**				
	Perkin MR		Bhaskaran K		Kahlberg A
	COVID-19	Non-COVID-19	COVID-19	Non-COVID-19	
Male (Ref = female)			OR = 1.2	OR = 1.5	
Older age (>60 years) (Ref = 50-59 years)			OR >2	OR >2	
Obese class III (Ref=not obese)			OR=3	OR=1.5	
Ex-smoker (Ref=Never)			OR=1.5	OR=1.5	
Current smoking (Ref=Never)			OR=1.1	OR=2.5	
Deprivation (level 2-5) (Ref= least deprived: level 1)			OR=1.1-2	OR=1.1-2	
Two comorbidities (Ref = non-comorbid)	OR=1.75	OR = 2.3			
Three comorbidities (Ref = non-comorbid)	OR=3.08	OR =6.46			
COVID (Ref=non-COVID)					OR=4.13
Controlled diabetes Uncontrolled diabetes (Ref=no diabetes)			OR=1.6 OR=2.2	OR=1.3 OR=2.0	
Cancer <1 year ago Cancer 1-4.9 years ago (Ref=no cancer)			OR=1.1 OR=1.5	OR=1.6 OR=3.5	

Table 2. 3 The impact of potential confounding factors on mortality (Cont.)

Factors	Studies				
	Perkin MR		Bhaskaran K		Kahlberg A
	COVID-19	Non-COVID-19	COVID-19	Non-COVID-19	
Hematological malignancy <1 year ago 1-4.9 years ago 5 years ago (Ref=no hematological malignancy)			 OR=2.5 OR=2.1 OR=1.8	 OR=6.0 OR=3.0 OR=1.8	
eGFR 30-36 eGFR 15-<30 eGFR <15-dialysis (Ref=eGFR>60)			OR=1.5 OR=3.0 OR=6.0	OR=1.3 OR=3.0 OR=6.1	
Asthma with recent OCS (Ref=no asthma)			OR=1.6	OR=1.2	
Chronic respiratory disease (Ref=none)			OR=1.9	OR=2.1	
Chronic cardiac disease (Ref=none)			OR=1.6	OR=1.7	
Hypertension (Ref=none)			OR=1.1	OR=1.1	
Chronic liver disease (Ref=none)			OR=2.3	OR=4.5	

Table 2. 3 The impact of potential confounding factors on mortality (Cont.)

Factors	**Studies**				
	Perkin MR		Bhaskaran K		Kahlberg A
	COVID-19	Non-COVID-19	COVID-19	Non-COVID-19	
Dementia (Ref=none)			OR=4.8	OR=3.5	
Stroke (Ref=none)			OR=2.0	OR=1.9	
Other neurological (Ref=none)			OR=3.1	OR=3.0	
Another transplant (Ref=none)			OR=5.1	OR=4.0	
Asplenia (Ref=none)			OR=1.5	OR=2.1	
rheum arthritis/lupus/psoriasis (Ref=none)			OR=1.3	OR=1.2	
Other immunosuppression (Ref=none)			OR=3.0	OR=3.5	
Emergency setting (Other setting)					OR=1357

Table 2. 4 The impact of potential confounding factors on ICU admission

Factors	Study
	Yeates EO
Older age (>65 years) (Ref=<65 years)	OR=1.69
COVID-19 period (Ref=non-COVID-period)	OR=0.82
Respiratory rate >22 breaths/minute (Ref=<22 breaths/minute)	OR=1.49

Table 2. 5 The impact of potential confounding factors on deferred care program implementation

Factors	Studies	
	Hennelly N	Lee J
Two or more chronic conditions (Ref= No chronic condition)	OR=1.46	
Female (Ref=male)	OR=1.25	PR=1.29 (Ref=female)
Third level education (Ref=Primary level education)	OR=1.61	
Lives with others (Ref=Lives alone)	OR=0.79	
Another urban setting (Ref=Dublin)	OR=0.69	
Medium/small and non-metro (Ref=Large central metro)		PR=0.82, 0.79

Table 2. 5 The impact of potential confounding factors on deferred care program implementation (Cont.)

Factors	Studies	
	Hennelly N	Lee J
Problematic alcohol consumption (Ref=No problematic alcohol consumption)	OR=1.54	
Both medical card and health insurance (Ref=No medical card or health insurance)	OR=0.68	PR=1.36-1.58
One or more GP visit (Ref=No GP visit)	OR=2.10	
Polypharmacy (Ref=No polypharmacy)	OR=1.37	
Age 45-64 years (Ref=Age 18-24 years)		PR=1.41
>high school (Ref=<high school)		PR=1.01-1.82
Employment (Ref=none)		PR=0.93
COVID (Ref=non-COVID)		PR=1.30
Diabetes (Ref=no diabetes)		PR=1.16
Obese (Ref=not obese)		PR=1.06
Hypertension (Ref=none)		PR=1.15

Table 2. 5 The impact of potential confounding factors on deferred care program implementation (Cont.)

Factors	Studies	
	Hennelly N	Lee J
COPD (Ref=none)		PR=1.14
Cancer (Ref=none)		PR=1.13
Arthritis (Ref=none)		PR=1.23
Asthma (Ref=none)		PR=1.21
COPD (Ref=none)		PR=1.14

Table 2. 6 The impact of potential confounding factors on telehealth program implementation

Factors	Study
	Lee J
Older age (>85 years) (Ref=18-24 years)	PR=0.87
>high school (Ref=<high school)	PR=1.09-1.13
Private insurance (Ref=non-health insurance)	PR=0.94
Non-metro (Ref=Large central metro)	PR=0.94
COVID (Ref=non-COVID)	PR=1.08
Diabetes (Ref=no diabetes)	PR=1.04

Table 2. 6 The impact of potential confounding factors on telehealth program implementation (Cont.)

Factors	Study
	Lee J
Cancer (Ref=none)	PR=1.06
Arthritis (Ref=none)	PR=1.05
Anxiety (Ref=none)	PR=1.06

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Methods

The methods used in this study were composed of 2 analytical parts: one to estimate clinical outcomes and another to address the economic outcomes from each care pathway. Figure 3.1 summarizes the conceptual framework for this study. The mutually exclusive and exhaustive set of four care pathways (the DC program, PAH program, DC+PAH program, and discharge home with follow-up at hospital) were evaluated to assess their clinical and economic outcomes and to make policy recommendations. For the clinical outcomes, the evaluation included missed appointments, failure to receive drugs, surrogate markers, and hospitalizations. Surrogate markers and hospitalizations were considered the primary outcomes as they were the main results of interest in the research. Missed appointments and failure to receive drugs were categorized as secondary outcomes. For economic outcomes, the result was measured solely as the cost of illness.

Figure 3.2 summarizes the methods employed in this thesis. Index cases were identified from the Saraburi hospital database. Patients with noncommunicable diseases (NCDs) who presented themselves to the outpatient department (OPD) were recruited over two time periods: (1) July 2021 to December 2021 reflecting the COVID-19 pandemic period; and (2) July 2022 to December 2022, the post-pandemic period. Patients were followed for 6 months from their date of recruitment. The use of each of the four mutually exclusive and exhaustive four care pathways was identified. Clinical and economic outcomes were compared between each care pathway. The selected statistical analysis for clinical outcomes in this study was multilevel analysis due to the presence of nested data from different care pathways. If the data are continuous, such as surrogate markers, multivariate multilevel mixed effects generalized linear models was used. For discrete data, multivariate multilevel mixed-effects logistic regression model was used. Multivariate log-linear regression model was used for economic outcome. The findings from this study were used to informed policy makers at the

MoPH regarding the implementation of care pathways for NCD patients in tertiary care hospital.

3.2 Research design

This study was retrospective cohort study.

3.2.1 Population

The study population comprised patients with NCDs who presented to the outpatient department at tertiary care hospital over the study periods.

3.2.2 Sample size determination

The studied samples were recruited from Saraburi hospital. The rule of thumb for regression analysis suggested a minimum of 50 participants, with the number increasing when there were more independent variables (62). In this study, there were eight independent variables considered as potential covariates for regression analysis: policies (the DC program, PAH program, DC+PAH program, and discharge home with follow-up at hospital), comorbidity, sex, age, medical benefit scheme, polypharmacy, body mass index (BMI), and COVID-19 disease (8,58-61). The sample size for regression analysis was 400 participants.

The unit of analysis in this study was the hospital visit.

3.2.3 Study time horizon

The time horizon of the study was ranged from July 01, 2021 to June 30, 2023. NCD patients who visited the outpatient department (OPD) between July 2021 and December 2021 were recruited and followed for 6 months until June 2022. Moreover, a second recruitment period occurred between July 2022 and December 2022. Patients were followed for 6 months until June 2023. The two study periods were selected to be representative of the COVID-19 pandemic and post-pandemic periods. This study examines the clinical and economic outcomes associated with these two periods.

3.2.4 Inclusion criteria

NCD patients who were visited the Saraburi hospital between July 01, 2021 and December 31, 2021, or between July 01, 2022 to December 31, 2022.

NCD patients on unchanged medication regimen in 6 months by checking from medication reconciliation.

NCD patients who had a principal diagnosis (PDX) and complications of diabetes mellitus (DM) and hypertension (HT).

3.2.5 Exclusion criteria

Participants who have a missing value to any of the study variables.

Participants with incorrect values for any study variable, e.g., age ≥ 110 years.

3.3 Data source and collection methods

3.3.1 Data source

The secondary data was retrieved from the administrative and clinical data stores at the Saraburi hospital.

3.3.2 Collection method

A case record form (CRF) was used in this study, as shown in Figure 3.3 and Appendix B. The CRF comprised demographic, clinical and economic data from the OPD, and hospitalization data from the inpatient department (IPD).

3.3.3 Validity and reliability

Incorrect medical records e.g., age ≥ 110 years were explored and excluded by the researcher.

Data consistency was assessed by comparing the electronic database of Saraburi hospital to the medical records.

3.4 Data analysis

3.4.1 Differences in patients' characteristic distribution

The difference in patients' characteristic distributions, including demographics, clinical and economic outcomes, among the four care pathways; the DC program, PAH program, DC+PAH program, and discharge home with follow-up at hospital, was assessed using descriptive data. The difference in category variable distribution was tested using the chi-squared or fisher extract test. The student t-test or Mann-Whitney U test were used to test for the mean difference between the continuous variables.

3.4.2 Cost analysis

3.4.2.1 Cost of illness

A societal cost of illness model per hospital visit and admission was adopted that consisted of three parts: direct medical costs (i.e. diagnosis, lab, medical, procedure, drugs, and hospitalization cost); direct non-medical cost (i.e. transportation, meal, and informal care cost); and indirect cost. Indirect cost was assessed based on the loss in productivity associated with health seeking behavior and was calculated based on the human capital approach (63). The calculation of cost of illness is presented in Table 3.1. The scope of illness for estimation cost of illness covered cost of principal diagnosis (PDX) and the complications of two diseases of interest.

(1) Direct medical costs

This study estimated economic outcomes of care pathways including cost of service organization and delivery, and cost of treatments (drug and other service costs). The cost of the service organization and delivery for discharge home with follow-up at the hospital pathway was a fixed fee that is consistent across all hospitals in Thailand (64), and it could be converted into a cost by multiplying it with the cost-to-charge ratio (CCR). Cost of service arrangement of PAH, DC and PAH+DC pathways need to estimate its unit cost per visit using empirical based costing.

Cost of treatment was categorized into drug costs and other service costs. All treatment costs were converted from treatment charge retrieved from the hospital database. Drug costs were calculated based on the calculation formula provided in the specific markup percentage announced by the Comptroller General's Department, which represented the actual costs and not reference values (Table 3.2) (64). Other service costs such as anesthetic, dietary, lab, procedure, rehabilitation, supply, x-ray, diagnosis, and general were multiplied by CCR to convert the reported charge to cost estimates. Health Technology Assessment (HTA) guidelines in Thailand recommended the use of a CCR of 1.63 (63,65).

(2) Direct non-medical costs

Transportation and meals costs were estimated based on HTA guidelines recommended in Thailand (63). Transportation and meals costs from the standard cost list for the Central or General hospitals were used because they are the closest reference values for tertiary care hospital (65). Those costs were converted to the present value using the consumer price index (CPI) announced by the Ministry of Commerce (66). Informal care cost was calculated based on time loss per hospital visit and then multiplied it by the gross national income (GNI) per capita.

(3) Indirect costs

This study included morbidity cost based on the human capital approach following the HTA guidelines recommended in Thailand (63). Time cost was calculated by the per capita GNI per day multiply by time loss for hospital visit and admission.

(4) Cost of health service

The unit cost of PAH and DC was calculated based on cost of outpatient pharmacy department and outpatient internal medicine department in Saraburi hospital from the Phase I and second year of the cost study of the Thai Case Mix Centre (TCMC) (67) divided by the number of visits of those patients who were receiving PAH or DC. The unit cost was converted to the present value using the consumer price index (GNI).

3.4.3 Factors affecting missed appointments, failure to receive drugs, normal-range surrogate markers, and hospitalizations.

Differences in the missed appointments, failure to receive drugs, hospitalization and normal-range surrogate marker between-groups were performed by the multivariate multilevel mixed-effects logistic regression (54). The multivariate multilevel mixed-effects logistic regression was chosen due to the policies associated with nested data from different care pathways. Prolonged exposure to these policies might lead to increasingly unfavorable clinical outcomes for patients (28,30,48).

The multivariate multilevel mixed-effects logistic regression was checked by model diagnostics including Heckman selection model, multicollinearity, goodness of fit and omitted variables. Stepwise backward elimination methods were explored for a multivariate model fit with the data. Goodness of fit test, Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), Log-likelihood ratio test, Root mean square error (RMSE) and receiver operating characteristic (ROC) curve were explored for measuring model fit and prediction model accuracy.

Equation 1 represents the formula used to create the dataset for dichotomous outcomes (54). The multilevel model assumed that there was a hierarchical data set, often consisting of subjects nested within groups, with outcome or response variable measured at the lowest level, and explanatory variables at all existing. This study consisted of two levels. The lowest level was "care pathways" and the highest level was "hospital number (HN)" The evaluation included measuring all clinical outcomes (Figure 3.3).

$$\text{logit}(\pi_{ij}) = \beta_0 + \beta_1 X_{ij} + F_{ij} + u_j + v_j(\text{covariate}_{ij}) \quad \text{_____} \quad 1$$

where;

• πij is $\Pr(\text{care pathway}_{ij} = 1)$

• i is the care pathways

• j is the cluster (HN)

• Fij is merely shorth and for the portion of the fixed-effects specification having to do with X variables.

• β is regression coefficients (fixed effects)

• uj is the random effects

• vj(covariate) is extending the model as adding covariate variable (the duration for

using care pathway in each VN) to the random-effects specification so that the model now includes a random intercept and a random coefficient on covariate variable.

3.4.4 Factors affecting surrogate markers and cost of illness

Multivariate multilevel mixed-effects generalized linear model was estimated the model for predict policies affecting surrogate markers (55) and the multivariate log-linear regression model (68) was estimated cost of illness while control all confounding factors constant. Final model was checked follows the assumption for normality and heteroscedasticity. The models fit used stepwise backward elimination method. Finally, the best predictive model was selected based on Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), Log-likelihood ratio, RMSE and R-squared.

Equation 2 and 3 represents the formula used to create the dataset for continuous outcomes. The multilevel model in this study is presented in Figure 3.3.

$$Y_{ij} = \beta_0 + \beta_1 X_{ij} + F_{ij} + u_j + v_j(\text{covariate}_{ij}) \_\_\_\_\_ 2$$

where;

• i the care pathway,

• j the cluster (HN),

• Y_{ij} the outcome for care pathway i in cluster j,

• Fij is merely shorth and for the portion of the fixed-effects specification having to do with X variables.

• β is regression coefficients (fixed effects)

• uj is the random effects

• vj(covariate) is extending the model as adding covariate variable (the duration for using care pathway in each VN) to the random-effects specification so that the model now includes a random intercept and a random coefficient on covariate variable.

The log transformed model can be written as the equation 3, expected y in log scale can be estimated by constant plus beta coefficient of the particular potential predictor variable.

$$\ln(y) = a+b1(x1) + b2(x2)+ b3(x1\times x2) \quad \text{_____} \quad 3$$

3.4.5 Nationwide impact of DC and PAH program

In this part, the cost results were extrapolated to obtain a nationwide figure of the policies impact. The formular for calculation overall outcomes (68,69) is shown in equation 4.

$$\text{Overall outcomes} = N \times \text{p-hat} \times \text{d-hat} \quad \text{_____} \quad 4$$

Overall outcomes = cost of illness

N = The population at risk of NCD patients at tertiary care hospital in Thailand

p-hat = Prevalence of NCD patients who get policies in this study

d-hat = Estimated excess cost of illness from policies provided by the multivariate log-linear regression model

The variance of estimated excess outcomes is shown in equation 5.

$$\text{Variance of outcomes} = N^2 \{(\text{p-hat}^2 \times V_d) + (\text{d-hat}^2 \times V_p) + (V_p \times V_d)\} \quad \text{_____} \quad 5$$

Variance of outcomes = cost of illness

N = The population at risk of NCD patients at tertiary care hospital in Thailand

p-hat = Prevalence of NCD patients who get policies in this study

d-hat = Estimated excess cost of illness from policies provided by the multivariate log-linear regression model

Vd = Variance of cost of illness from policies provided by the multivariate log-linear regression model

Vp = Variance of estimate prevalence rate of patients who get policies in this study

The 95% CI of variance of excess outcomes from policies is shown in equation 6.

$$95\%\ \text{CI of variance of outcomes} = N \pm 1.96\ (\text{sqrt}\ (V_{\text{of outcomes}})) \quad \text{_____} \quad 6$$

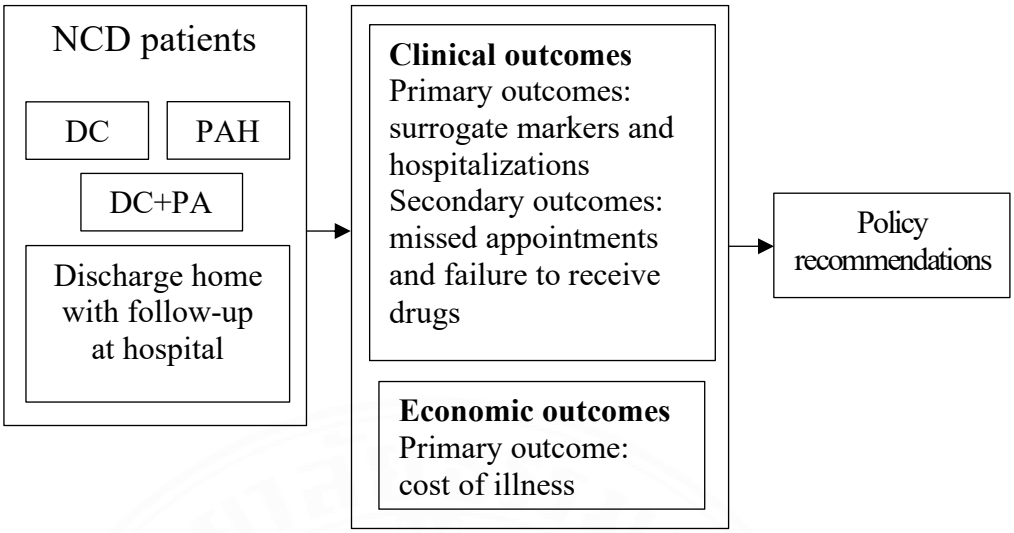

Figure 3. 1 Conceptual framework

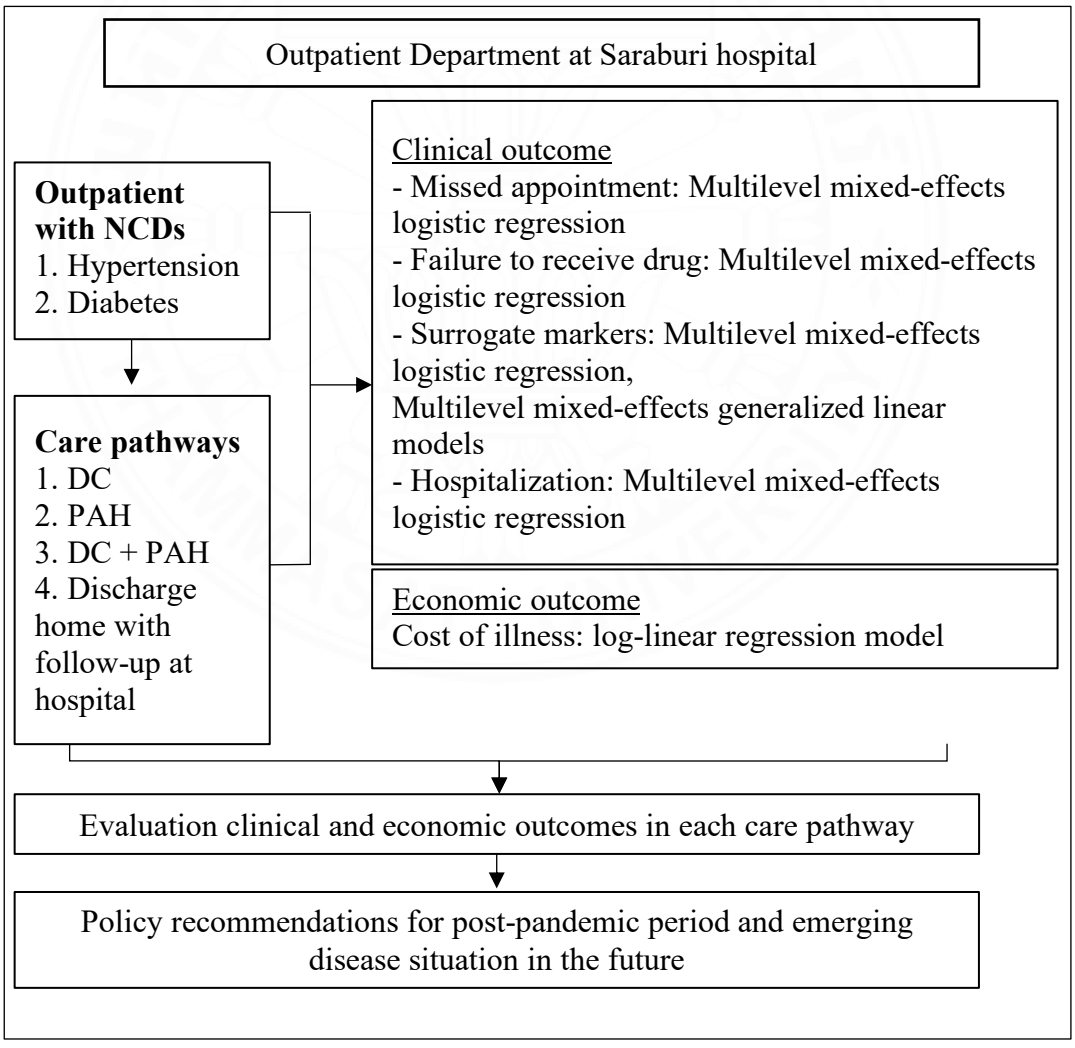

Figure 3. 2 Summarization of the method

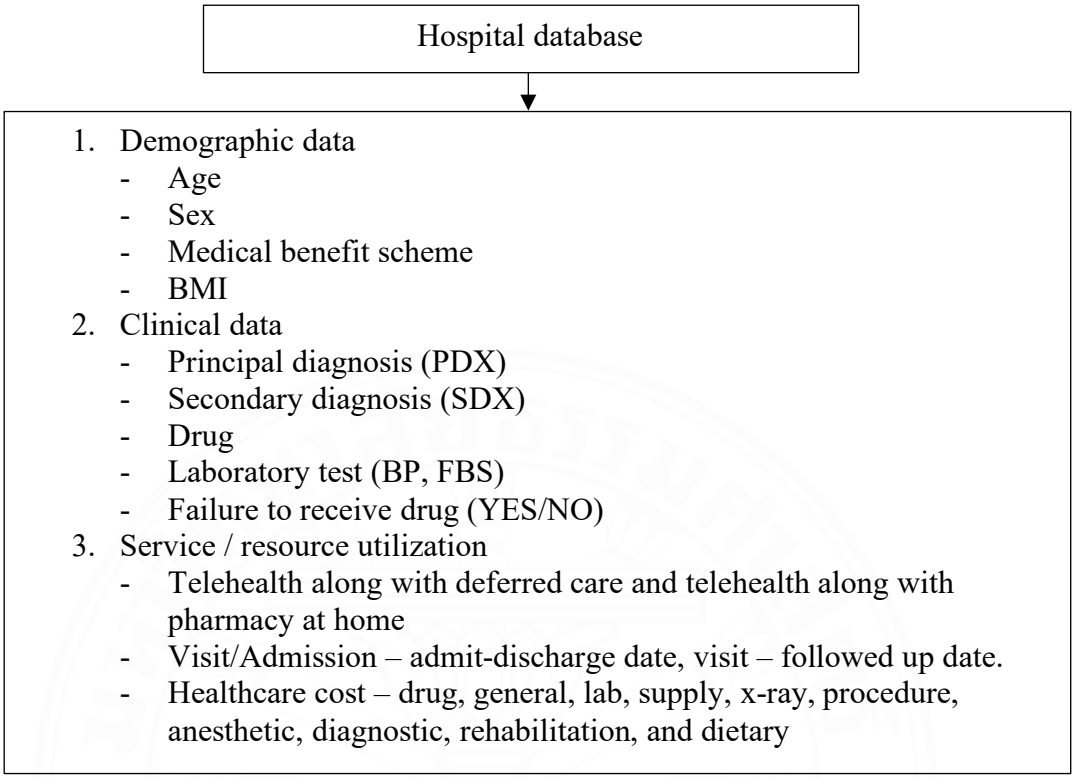

Figure 3. 3 Data in CRF from hospital database

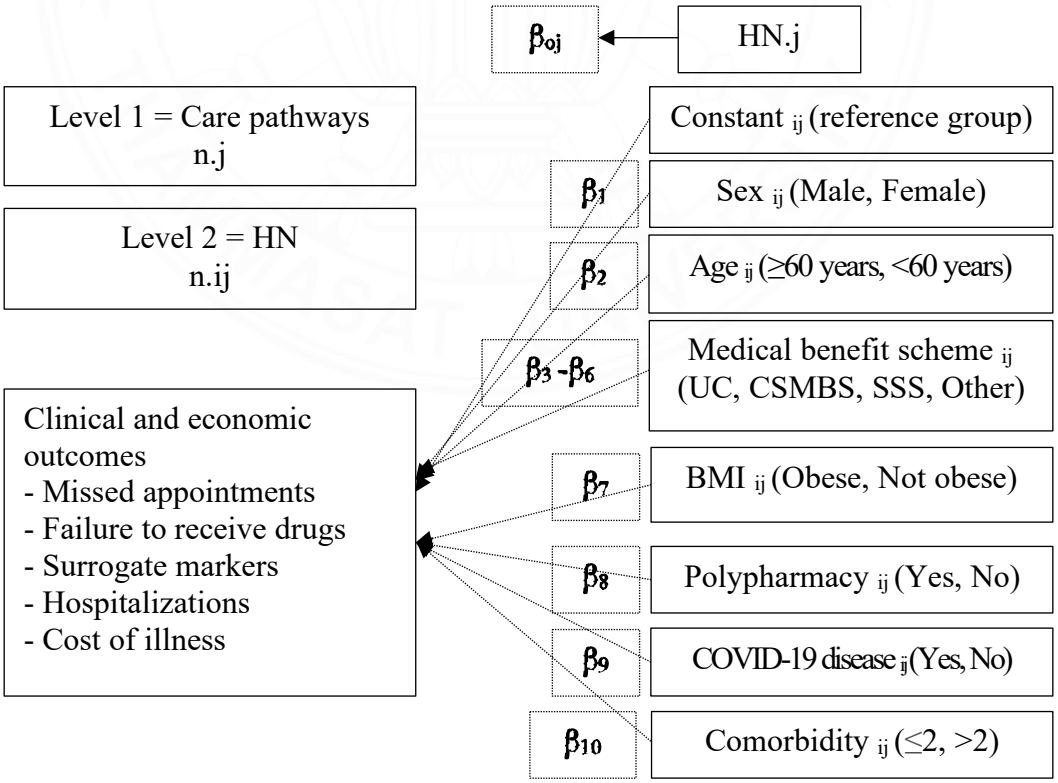

Figure 3. 4 Multilevel model

Table 3. 1 Cost of illness in societal perspective

Cost	Calculation
Direct medical cost	
Telehealth with pharmacy at home	Unit cost of service arrangement
Deferred care	Unit cost of service arrangement
Discharge home with follow-up at the hospital pathway	Cost to charge ratio
Anesthetic	Cost to charge ratio
Dietary	
Lab	
Procedure	
Rehabilitation	
Supply	
x-ray	
Diagnostic	
General	
Drug	The formula by the Comptroller General's Department
Direct non-medical cost	
Transportation	Reference values
Meals	
Informal care	Productivity cost
Indirect cost	
Morbidity cost	Productivity cost

Table 3. 2 Drug cost calculation

Drug cost	Reimburse price calculation
0.01 - 0.20	0.50
0.21 - 0.50	1.00
0.51 - 1.00	1.50
1.01 - 10.00	1.50 + 125% (cost over 1.00)
10.01 - 100.00	13 + 120% (cost over 10.00)
100.01 - 1,000.00	126 + 115% (cost over 100.00)
> 1,000	1,161 + 110% (cost over 1,000.00)

- If charge price is less than 10 THB, rounds up to time of 0.25 THB.
- If charge price is greater than 10 THB and not greater than 100 THB, rounds up to time of 0.50 THB.
- If charge price is greater than 100 THB, rounds up or down to 1 THB depends on greater or less than 0.50 THB.

CHAPTER 4
RESULTS AND DISCUSSION

Chapter four is divided into 4 sections that report:

4.1 Sample description

4.2 Descriptive analysis

4.3 Care pathways affecting surrogate markers

4.4 Nationwide impact

4.5 Limitations

4.1 Sample description

This section reports our study results. The study population comprised NCD patients (diabetes and hypertension patients) who presented to the outpatient department of Saraburi Hospital; a tertiary care institution in Thailand. We conducted retrospective data collection, based on ICD-10 codes I10, E119, E129, E139 and E149, for two study periods: (1) July 2021 to December 2021; and (2) July 2022 to December 2022.

NCD patients who visited Saraburi Hospital with diabetes DM and HT between July 1, 2021, and December 31, 2021, without complications totaled 8,030 visit number (VN), while those between July 1, 2022 and December 31, 2022 totaled 13,335 VN. After excluding patients who had changes in their medication regimen within six months, the remaining patients were 3,718 and 4,500 VN, respectively. After further excluding participants with missing values for any study variables and those with incorrect values, the number of remaining patients was 3,530 and 4,140 VN, respectively. Finally, after removing the PAH+DC group due to the small sample size, the final number of patients was 3,518 and 4,135 VN for each respective period.

We collected hospitalization data for 7,653 patients visit number for six-months from study enrollment as outlined in Chapter III. In the first period, July 2021 to December 2021, 318 patients (9.04%) were identified in the DC program, 297 patients (8.44%) were identified in the PAH program, and 2,903 patients (82.52%)

were identified in the discharge home with follow-up at the hospital program. In the second period, July 2022 to December 2022, 251 patients (6.07%) were identified in the DC program, 143 patients (3.46%) were identified in the PAH program, and 3,741 patients (90.47%) were identified in the discharge home with follow-up at the hospital program. The DC+PAH program was discontinued from the study because there were very few patients in this group in both periods. Therefore, patients in DC and PAH programs were not considered and not included in this study.

4.2 Descriptive analysis

Descriptive analysis was performed to identify the differences in the distribution of patients' characteristics, including demographic and clinical characteristics in each pathway. Moreover, we performed descriptive analysis to report clinical and economic outcomes including missed appointments, failure to receive drugs, surrogate markers (blood pressure (BP) and fasting blood sugar (FBS)), hospitalizations and cost of illness in each pathway. Missed appointments, failure to receive drugs, and hospitalizations were reported as the number of patients experiencing the events and percentages only. Since the occurrence of events in each group was low, inferential statistics could not be used for comparisons.

Most patients across the periods were female, older than 60 years of age, with a body mass index (BMI) exceeding 25 kg/m^2, enrolled in the Universal Coverage (UC) scheme, not on polypharmacy, had more than two comorbidities and had not encountered COVID-19 (Table 4.1-4.2).

Most of the patients in this study experienced missed appointments, failure to receive drugs, and hospitalizations more frequently in the PAH and DC programs compared to the discharge home with follow-up at the hospital program. The percentage of missed appointments, failure to receive drugs, and hospitalizations was highest in the PAH program (Table 4.3-4.5).

Missed appointments

For the missed appointment outcomes from the index case between July 2021 and December 2021, 6.23% occurred in the discharge home with follow-up at hospital program, 11.11% in the PAH program, and 4.09% in the DC program. The

percentages represented the proportion of patients who missed their appointments within each care pathway. For the missed appointment outcomes from the index case between July 2022 and December 2022, 5.99% occurred in the discharge home with follow-up at hospital program, 6.99% in the PAH program, and 5.18% in the DC program. Based on previous studies, the rate of missed appointments in the DM patient group was about 3%, while in the HT group was about 5% (70). This aligns with the current study, which found that during the COVID-19 pandemic and post pandemic, the rate of missed appointments among patients in discharge home with follow-up at hospital was approximately 5-6%, similar to the DC group. However, in the PAH group during the COVID-19 pandemic, the rate of missed appointments increased to 11%, but decreased to about 7% in the post-pandemic period. The reason for the higher rate of missed appointments in PAH program during the COVID-19 pandemic might be attributed to communication system issues (33,71), as PAH were not conducted in the usual manner at hospitals. While there were ongoing adjustments in the details, the main system remained unchanged. This study did not include a qualitative analysis. Patients may have had sufficient leftover medications at home, which could explain the missed appointments. However, in the post-pandemic period, the rate of missed appointments decreased. Moreover, missed appointment outcomes were determined based on the protocol of Saraburi Hospital, which did not specify the number of days. These outcomes were identified through the hospital's computer system by checking whether patients attended their scheduled appointments. However, some patients might have had remaining medications and were in good health, which could have led to an overestimation of missed appointments.

Failure to receive medication

For failure to receive drug outcomes from the index case between July 2021 and December 2021, 0.45% occurred in the discharge home with follow-up at hospital program, 1.68% in the PAH program, and 2.20% in the DC program. The percentages represent the proportion of patients who failed to receive drug within each care pathway. For failure to receive drug outcomes from the index case between July 2022 and December 2022, 0.51% occurred in the discharge home with follow-up at hospital program, 1.40% in the PAH program, and 0.80% in the DC program. Previous studies indicated that the rate of failure to receive medication was around 15-20% (72).

However, this study focused on patients with stable symptoms, who are likely to be more engaged in their treatment, the rate of failure to receive medication is lower. Specifically, the rate of failure to receive medication among patients discharged home with follow-up at the hospital was approximately 0.5% in both periods. However, the rates of failure to receive medication for PAH and DC programs were higher during the COVID-19 pandemic and decreased in the post-pandemic period, with DC dropping to 0.8% while PAH remained higher at 1.4%. This might be due to a reduction in the interaction between healthcare providers and patients led to lack of clear communication, reduced monitoring, and decreased motivation (33,71).

Hospitalization

For the hospitalization outcomes from the index case between July 2021 and December 2021, 0.96% occurred in the discharge home with follow-up at hospital program, 1.35% in the PAH program, and 1.26% in the DC program. The percentages represented the proportion of patients who were hospitalized within each care pathway. For the hospitalization outcomes from the index case between July 2022 and December 2022, 0.67% occurred in the discharge home with follow-up at hospital program, 0.70% in the PAH program, and 0.40% in the DC program. Previous studies showed that the rate of emergency department (ED) visits occurred at around 30-40% (43). However, this study selected only patients with stable symptoms for at least 6 months, resulting in a lower rate of hospitalization, approximately 1% during the COVID-19 pandemic, and decreasing to no more than 0.7% across all care pathways in the post-pandemic period.

The PAH program had a higher rate of missed appointments and failure to receive medications compared to other care pathways. This may be due to the complexity of the PAH system, as mentioned in Chapter 2 (33,71). However, these incidents decreased in the post-pandemic period. Additionally, these incidents did not lead to an increase in hospitalization rates. Even though hospitalization rates appeared to rise during the COVID-19 pandemic, this trend was observed across all care pathways and decreased in the post-pandemic period.

In both study periods (Table 4.6-4.7), most of patients had a systolic BP <140 mmHg, diastolic BP <80 mmHg, and FBS <140 mm/dL. Changes in BP and FBS from baseline were minimal, with the median values ranging between -2.5 and 1. There

was a significant difference in cost of health service (COH) and cost of illness (COI) distribution in both periods. The median of COH in the PAH program was higher than the discharged home with follow-up at the hospital and DC programs. Moreover, the median of COI in the discharged home with follow-up at the hospital program was higher than PAH and DC program (Table 4.8-4.9).

4.3 Care pathways affecting surrogate markers and costs

4.3.1 Care pathways affecting surrogate markers

Model diagnosis was handled within multilevel statistics. In this study, the inverse Mills ratio (IMR) term from the Heckman selection model consisted of two parts: a selection effect and an effect due to endogeneity. It was also computed from the probit regression results (73). In this study, selection bias was assessed across the three care pathways: the discharged home with follow-up at the hospital program, PAH, and DC in patients with DM and HT, with pairwise comparisons between care pathways. The results indicated no selection bias, as the IMR values were not statistically significant, except for the comparison between the discharged home with follow-up at the hospital program and the combined PAH and DC pathways in patients diagnosed with HT (Appendix C Table 1-12). There were potential covariates that should have been included in the model to assess selection bias. However, due to limitations in data collection, some of these covariates were not included in the model. Therefore, the application of the model should be approached with caution.

AIC, BIC, Log-likelihood ratio, RMSE and R-squared were used to predict the best model. Multivariate multilevel mixed-effects linear regression was used to explain the association between the interested care pathways and the target/non-target surrogate markers while holding all other confounding factors constant. AIC, BIC, Log-likelihood ratio, and receiver operating characteristic (ROC) curve were used to predict the best model. The confounding factors were sex, age, medical benefit scheme, BMI, polypharmacy, COVID-19 disease and comorbidities. Multilevel analysis was used due to the presence of nested surrogate marker data from different care pathways.

The R-squared from the multivariate multilevel mixed-effects linear regression models in this study was over 0.8, indicating that more than 80% of the variation in the dependent variable could be explained by the model (74). In contrast, the ROC from the multivariate multilevel mixed-effects logistic regression models in this study was below 0.7, indicating a model with limited discriminative ability (equivalent to random guessing) (75). Therefore, this study used the results from the multivariate multilevel mixed-effects linear regression models, as it indicates a better fit to the data. The models are shown in Table 4.10-4.12 and Appendix C, Table 13-15. The multivariate multilevel mixed-effects logistic regression models that best fit the data are presented in Appendix C, Tables 16-18.

The multivariate multilevel mixed-effects linear regression showed that the care pathways were not impacted to the changes of SBP, DBP, and FBS in both COVID-19 pandemic and post-pandemic period. The model on SBP is shown in Table 4.10 (Log likelihood = -14830.61, RMSE = 17.47, AIC = 29691.23, BIC = 29783.49, R-squared = 0.80 in COVID-19 pandemic period and Log likelihood = -17069.268, RMSE = 15.45, AIC = 34162.54 , BIC = 34238.38, R-squared = 0.99 in post-pandemic period). The model on DBP is shown in Table 4.11 (Log likelihood = -14060.65, RMSE = 13.99, AIC = 28145.3, BIC = 28219.11, R-squared = 0.98 in COVID-19 pandemic period and Log likelihood = -14060.65, RMSE = 13.99, AIC = 28145.3, BIC = 28219.11, R-squared = 0.98 in post-pandemic period). The model on FBS is shown in Table 4.12 (Log likelihood = -8711.77, RMSE = 34.59, AIC = 17455.54, BIC = 17543.07, R-squared = 0.99 in COVID-19 pandemic period and Log likelihood =

-9708.56, RMSE = 34.57, AIC = 19449.12, BIC = 19538.46, R-squared = 0.99 in post-pandemic period)

There were two studies in Thailand comparing the PAH program during the COVID-19 outbreak and standards of care in secondary hospitals. A paired t-test and Wilcoxon rank sum test were a statistical test that is used to compare the mean or median of two dependent groups in two studies. These studies found that there was no statistically significant difference in the clinical outcomes (average blood pressure and HbA1c levels) before and after receiving the PAH programs which were consistent with this research (15,16).

In summary, this study shown that the use of the PAH and DC programs resulted in no statistically significant difference in all clinical outcomes compared to the discharged home with follow-up at the hospital program. The similar inclusion criteria for the PAH and DC programs, which required patients to have stable symptoms and approval from the physician, the longest duration for receiving these two policies were not defined. This research further analyzed to affirm about the appropriate duration of PAH and DC programs by defining the cut-off-point for desired target clinical outcomes of interest following the guideline of American Diabetes Association (ADA) and European Society of Hypertension (ESH) as 140 mmHg for SBP, 80 mmHg for DBP, and 130 mg/dL for FBS (76,77). Univariate logistic regression was performed to assess the impact of duration for receiving the PAH and DC program on the desired clinical outcomes. Based on various duration for receiving the PAH and DC programs, the clinical outcomes were still as desired criteria compared to the discharged home with follow-up at hospital program. However, the mode of duration for receiving the PAH and DC programs were 5 months and 1 month, respectively. Therefore, the PAH and DC programs would be useful for at least 5 months and 1 month, respectively, without worsening in clinical outcomes (Appendix C, Table 19-21).

4.3.2 Care pathways affecting costs

The study provided the cost of illness model estimated from a societal perspective. COI comprised 3 parts: direct medical costs, direct non-medical cost and indirect cost. The method for calculating the cost of illness was presented in detail in

Chapter 3. The discharge home with follow-up at the hospital included all three parts in the COI calculation, while the PAH and DC programs included only direct medical costs in the COI calculation. For the DC program, only COH was included in direct medical costs, as patients already had their medication and only called to reschedule appointments.

Multivariate log-linear regression model was performed to explain the association between the particular potential predictor variable and the cost outcomes while holding all other confounding factors constant. AIC, BIC, Log-likelihood ratio, RMSE and R-squared were used to predict the best model. The confounding factors were sex, age, medical benefit scheme, BMI, polypharmacy, COVID-19 disease and comorbidities. The R-squared from the cost models in this study was over 0.8. The multivariate log-linear regression model showed that the DC and PAH pathway lowered COI than discharge home with follow-up at hospital program in both COVID-19 pandemic and post-pandemic period. The previous study (29) reported the use of telehealth intervention and benefits in reducing the cost of healthcare services and patients' out of pocket. Cost of healthcare services included equipment, building supplies, and wages. Patients' out of pocket included transportations, meals, and accommodations. The systematic review study of cost-effectiveness analysis of telehealth found that telehealth was claimed to be cost-effective (45). The cost model is shown in Table 4.13 (Log likelihood = -1635.12, RMSE = 0.39, AIC = 3294.23, BIC = 3368.22, R-squared = 0.81 in COVID-19 pandemic and Log likelihood = -2022.56, RMSE = 0.40, AIC = 4069.123, BIC = 4145.053, R-squared = 0.80 in post-pandemic period).

4.4 Nationwide impact

Table 4.14 reports the estimated annual number of stable HT and DM patients in 36 tertiary care hospitals in Thailand. The data was estimated from the Health Data Center (HDC) service of the Ministry of Public Health, Thailand in the year 2023 (78). The prevalence of NCD patients who got policies in this study was calculated from follows formula;

Number of patients who got policies/Total population

The variance of the estimated prevalence rate of patients who got the policy was calculated from the se^2*N

The nationwide estimation of excess annual costs from interested policies was reported in Table 4.15 and 4.16. The formulas used for the calculations are as follows:

1. Conditional costs = exp(constant + beta coefficient)

2. Variance of conditional cost = exp(var_beta coefficient)

3. Overall costs = Prevalence rate of interest policies x Conditional costs x Overall cases

4. Variance of overall costs = Overall N^2 x {(Prevalence rate of interest policies^2 x Variance of conditional costs) + (Conditional cost^2 x Variance of prevalent rate of interest policies) + (Variance of prevalent rate of interest policies x Variance of conditional costs)}

5. 95% CI of variance of overall costs= Overall costs ± 1.96(sqrt(Variance of overall costs))

There was a study using multivariate regressions model to estimate economic burden of interested disease (68,69). This study estimated the multivariate log-linear regressions model for economic outcomes in order to control all potential confounding factors. The results from this part were then used to calculate the nationwide estimation of annual costs for each care pathway in COVID-19 pandemic and post pandemic.

Conditional cost on PAH program was approximately 1,600-2,000 THB and conditional costs on DC program was approximately 100-200 THB. In terms of excess annual cost, 55.80 million THB per year was spent on the PAH and 5.62 million THB per year was spent on the DC program in COVID pandemic period. For the post-pandemic period, 21.64 million THB per year was spent on the PAH and 2.37 million THB per year was spent on the DC program (Table 4.15). It could be observed that during the COVID pandemic period, the budget used in PAH and DC was twice that of the post-pandemic period. Therefore, in the case of an emergency situation, proper planning for budget allocation was essential.

4.5 Limitations

The limitations of this study are discussed as follow:

First, selection bias in the allocation of patients to different care pathways was detected through statistical analysis, despite the study's focus on patients with diabetes and hypertension without complications. This type of selection bias was inherent in practical patient allocation and commonly observed. However, it did not compromise patient safety.

Second, this study included only DM and HT patients without complications, as the intervention groups of interest, PAH and DC, must be stable. Therefore, the study results will not be applicable to the DM and HT population with complications.

Third, there was no long-term study; this research followed the sample group for only 6 months. The PAH program was mostly used for 5 months, while the DC program was used for only 1 month. The absence of a long-term study makes it challenging to assess the long-term efficacy or potential drawbacks of the PAH and DC program.

Fourth, estimating the effect of care pathways on clinical outcomes requires multicenter studies. Our study had a limited budget and time, which were not sufficient to conduct multicenter studies.

Fifth, in the first instance, the care pathway was divided into four groups: Discharge home with follow-up at the hospital, PAH, DC, and PAH+DC. However, due to the small sample size in the PAH+DC group, it was excluded from consideration. If a multicenter study were conducted, it could provide a sufficient sample size. If the sample size were sufficient and data on the PAH+DC pathway could be collected, there might be no selection bias in Limitation 1.

Sixth, statistical analysis could not be used to predict certain clinical outcomes based on the predefined hypothesis, including missed appointments, failure to receive drugs, and hospitalizations, due to the low number of occurrences. Consequently, the data did not meet the statistical assumptions, and the results could only be reported as percentages.

Seven, there were other care pathways that were of interest, but they were not commonly found at Saraburi Hospital. These might vary depending on the context of each hospital. A multicenter study would help identify more care pathways and provide more comprehensive study results.

Eight, data in this study was from a tertiary hospital that did not reflect primary and secondary hospital. This lack of representation could impact the applicability of the findings to broader healthcare settings, as patient populations, resources, and care practices might differ significantly between these types of hospitals.

Ninth, there were other covariates, such as smoking, drinking, education, and caregiver status that may have an impact according to literature reviews. However, the available database did not allow for data collection. This presents an opportunity for future research to include these covariates, enhancing the analysis and potentially leading to more comprehensive findings. Moreover, covariates could be grouped in various ways. This study ensured consistent grouping across all models throughout the study. The grouping was based on previous research, but alternative grouping methods are possible, which could lead to different outcomes.

Table 4. 1 Demographic characteristics between July 2021 and December 2021

Parameters	Patients (N%)			*p-value*
	Discharge home with follow-up at hospital	PAH	DC	
Demographic characteristics between July 2021 and December 2021 (COVID-19 pandemic)				
Male sex, n (%)	1,062 (36.58)	91 (30.64)	126 (39.62)	0.057**
Age (years), median (IQR)	60 (53,68)	66 (50,70)	62 (52,67)	0.992*
Age (years), <60, n (%)	1,455 (50.12)	142 (47.81)	154 (48.43)	0.661**
BMI (kg/m^2), median (IQR)	26.90 (24.09,30.67)	27.34 (23.53,31.59)	26.91 (24.27,30.81)	0.514*
BMI <25 (kg/m^2), n (%)	985 (33.93)	101 (34.01)	101 (31.76)	0.736**
Medical benefit scheme, n (%)				
UC	1,442 (49.67)	98 (33.00)	160 (50.31)	<0.001**
SSS	843 (29.04)	103 (34.58)	73 (22.96)	
CSMBS	495 (17.05)	86 (28.96)	67 (21.07)	
Other	123 (4.24)	10 (3.37)	18 (5.66)	

* kruskal wallis test ** Chi-square test

Table 4. 2 Demographic characteristics between July 2022 and December 2022

Parameters	Patients (N%)			*p-value*
	Discharge home with follow-up at hospital	PAH	DC	
Demographic characteristics between July 2022 and December 2022 (Post-pandemic)				
Male sex, n (%)	1,353 (36.17)	42 (29.37)	105 (41.83)	0.042**
Age (years), median (IQR)	60 (53,68)	66 (58,73)	62 (54,69)	<0.001*
Age (years) <60, n (%)	1,871 (50.01)	43 (30.07)	111 (44.22)	<0.001**
BMI (kg/m^2), median (IQR)	26.84 (24.03,30.38)	27.5 (24.51,31.11)	26.80 (24.13,30.15)	0.180*
BMI (kg/m^2), <25 ,n (%)	1,238 (33.09)	40 (27.97)	84 (33.47)	0.434**
Medical benefit scheme, n (%) UC SSS CSMBS Other	 1,806 (48.28) 1,095 (29.27) 697 (18.63) 143 (3.82)	 59 (41.26) 14 (9.79) 67 (46.85) 3 (2.10)	 133 (52.99) 46 (18.33) 57 (22.71) 15 (5.98)	<0.001**

* kruskal wallis test

** Chi-square test

Table 4. 3 Missed appointments

Pathways	COVID-19 pandemic	Post-pandemic
	N (%)	N (%)
Discharge home with follow-up at hospital	181 (6.23%)	224 (5.99%)
PAH	33 (11.11%)	10 (6.99%)
DC	13 (4.09%)	13 (5.18%)

Table 4.4 Failure to receive drug

Pathways	COVID-19 pandemic	Post-pandemic
	N (%)	N (%)
Discharge home with follow-up at hospital	13 (0.45%)	19 (0.51%)
PAH	5 (1.68%)	2 (1.40%)
DC	7 (2.20%)	2 (0.8%)

Table 4. 5 Hospitalizations

Pathways	COVID-19 pandemic	Post-pandemic
	N (%)	N (%)
Discharge home with follow-up at hospital	28 (0.96%)	25 (0.67%)
PAH	4 (1.35%)	1 (0.70%)
DC	4 (1.26%)	1 (0.40%)

Table 4. 6 Clinical characteristics between July 2021 and December 2021

Parameters	Patients (N%)			*p-value*
	Discharge home with follow-up at hospital	PAH	DC	
Clinical characteristics between July 2021 and December 2021 (COVID-19 pandemic)				
Medicine, median (IQR)	5 (3,7)	4 (3,7)	5 (3,8)	0.005*
Polypharmacy, n (%)	1,208 (41.61)	111 (37.37)	154 (48.43)	0.017**
>2 comorbidities, n (%)	1,865 (64.24)	178 (59.93)	280 (88.05)	<0.001**
Had a history of COVID-19 infection, n (%)	234 (8.06)	25 (8.42)	17 (5.35)	0.216

Table 4. 6 Clinical characteristics between July 2021 and December 2021 (Cont.)

Parameters	Patients (N%)			*p-value*
	Discharge home with follow-up at hospital	PAH	DC	
Changes systolic BP, median (IQR)	0 (-9,10)	-2.5 (-11,8)	0 (-10,10)	0.137*
Changes diastolic BP, median (IQR)	0 (-8,8)	1 (-8,8)	0 (-7,8)	0.636
Changes FBS, median (IQR)	0 (-12,13)	1 (-12,11)	1 (-10,10)	0.913*
Systolic BP (≥140 mmHg), n (%)	1,146 (39.50)	141 (52.22)	123 (41.69)	<0.001**
Diastolic BP (≥80 mmHg), n (%)	1369 (47.19)	149 (55.19)	156 (52.88)	0.011**
FBS (≥130 mm/dL), n (%)	593 (46.88)	67 (28.88)	74 (28.57)	<0.001**

* kruskal wallis test, ** Chi-square test, *** Multicriteria

Table 4. 7 Clinical characteristics between July 2022 and December 2022

Parameters	Patients (N%)			*p-value*
	Discharge home with follow-up at hospital	PAH	DC	
Clinical characteristics between July 2022 and December 2022 (Post-pandemic)				
Medicine, median (IQR)	5 (3,7)	6 (5,9)	5 (3,8)	<0.001*
Polypharmacy, n (%)	1,688 (45.12)	91 (63.64)	125 (49.80)	<0.001**
>2 comorbidities, n (%)	2,260 (60.41)	123 (86.01)	210 (83.67)	<0.001**
Had a history of COVID-19 infection, n (%)	574 (15.34)	19 (13.29)	46 (18.33)	0.344**
Changes systolic BP, median (IQR)	0 (-9,9)	1 (-11,12)	1 (-8,9)	0.966*
Changes diastolic BP, median (IQR)	0 (-7,7)	0 (-6,8)	0 (-8,8)	0.869*
Changes FBS, median (IQR)	1 (-13,14)	-1 (-12,7)	0 (-10,10)	0.372*
Systolic BP (≥140 mmHg), n (%)	1,296 (34.87)	79 (55.24)	90 (36.44)	<0.001**
Diastolic BP (≥80 mmHg), n (%)	1,622 (43.64)	65 (45.45)	116 (46.96)	0.553**
FBS (≥130 mm/dL), n(%)	1,129 (69.48)	93 (75.61)	148 (67.89)	0.300**

* kruskal wallis test, ** Chi-square test, *** Multicriteria

Table 4. 8 Cost outcomes between July 2021 and December 2021

Parameters	Patients (N%)			*p-value*
	Discharge home with follow-up at hospital	PAH	DC	
Cost outcomes between July 2021 and December 2021 (COVID-19 pandemic)				
COH, median (IQR)	764.98 (751.24,764.98)	1217.16 (1217.16,2435.95)	192.73 (177.34, 192.73)	<0.001*
Direct medical cost, median (IQR)	1735.24 (1294.98, 2626.28)	2537.95 (1814.26,3209.95)	192.73 (177.34, 192.73)	<0.001*
Direct non-medical cost, median (IQR)	1028.28 (1028.28, 1028.28)	-	-	-
Indirect cost, median (IQR)	683.17 (683.17, 683.17)	-	-	-
COI, median (IQR)	3446.69 (3006.43, 4337.73)	2537.95 (1814.26,3209.95)	192.73 (177.34, 192.73)	<0.001*

* kruskal wallis test

Table 4. 9 Cost outcomes between July 2022 and December 2022

Parameters	Patients (N%)			*p-value*
	Discharge home with follow-up at hospital	PAH	DC	
Cost outcomes between July 2022 and December 2022 (Post-pandemic)				
COH, median (IQR)	692.61 (626.14,692.61)	1126.76 (1126.76,1126.76)	183.12 (52.32,183.12)	<0.001*
Direct medical cost, median (IQR)	1499.58 (1104.71,1659.48)	1893.26 (1659.48,2926.56)	183.12 (52.32,183.12)	<0.001*
Direct non-medical cost, median (IQR)	1057.98 (1057.98, 1057.98)	-	-	-
Indirect cost, median (IQR)	696.66 (696.66, 696.66)	-	-	-
COI, median (IQR)	3254.25 (2859.35,4390.98)	1893.26 (1659.48,2926.56)	183.12 (52.32,183.12)	<0.001*

* kruskal wallis test

Table 4. 10 Multivariate multilevel mixed-effects linear regression on systolic blood pressure

Parameters	Coefficient	SE	95%CI	*p*-value
July 2021 and December 2021 (The covid-19 pandemic period) , $R^2 = 0.80$, stepwise model				
Care pathways				
-Discharge home with follow-up at hospital pathways	-	-	-	-
-PAH	-1.23	1.11	-3.41 - 0.95	0.272
-DC	0.27	1.13	-1.95 - 2.50	0.811
Sex				
Male	-	-	-	-
Female	0.23	0.62	-1.20 - 1.24	0.970
Age (years)				
Age < 60	-	-	-	-
Age ≥ 60	1.94	0.70	0.57 - 3.33	0.006
BMI group (kg/m^2)				
BMI < 25	-	-	-	-
BMI ≥ 25	1.29	0.64	0.04 - 2.54	0.043
Polypharmacy				
No	-	-	-	-
Yes	0.65	0.64	-0.61 - 1.90	0.312
Comorbidities (diseases)				
≤2	-	-	-	-
> 2	-1.79	0.68	-3.12 - -0.47	0.008

Table 4. 10 Multivariate multilevel mixed-effects linear regression on systolic blood pressure (Cont.)

Parameters	Coefficient	SE	95%CI	*p*-value
Schemes				
UC	-	-	-	-
SSS	-0.69	0.77	-2.20 - 0.81	0.367
CSMBS	-0.16	0.83	-1.78 - 1.46	0.845
Other	0.83	1.50	-2.11 - 3.77	0.580
July 2022 and December 2022 (The post-pandemic period), $R^2 = 0.99$, full model				
Care pathways				
-Discharge home with follow-up at hospital pathways	-	-	-	-
-PAH	-0.15	1.33	-2.76 - 2.46	0.910
-DC	0.03	1.02	-1.98 - 2.03	0.979
Sex				
Male	-	-	-	-
Female	-0.46	0.51	-1.45 - 0.53	0.363
Age (years)				
Age < 60	-	-	-	-
Age ≥ 60	0.32	0.55	-0.77 - 1.41	0.565
BMI group (kg/m^2)				
BMI < 25	-	-	-	-
BMI ≥ 25	-1.38	0.52	-2.39 - -0.36	0.008
Polypharmacy				
No	-	-	-	-
Yes	0.59	0.51	-0.42 - 1.60	0.249

Table 4. 10 Multivariate multilevel mixed-effects linear regression on systolic blood pressure (Cont.)

Parameters	Coefficient	SE	95%CI	*p*-value
Comorbidities (diseases)				
≤2	-	-	-	-
> 2	-0.33	0.54	-1.39 - 0.73	0.544
Schemes				
UC	-	-	-	-
SSS	-0.002	0.66	-1.29 - 1.29	0.998
CSMBS	-0.67	0.65	-1.94 - 0.61	0.305
Other	-1.82	1.27	-4.32 - 0.68	0.153
History of COVID-19 infection	-	-	-	-
Yes	-0.08	0.67	-1.40 - 1.23	0.900
No				

Table 4. 11 Multivariate multilevel mixed-effects linear regression on diastolic blood pressure

Parameters	Coefficient	SE	95%CI	*p*-value
July 2021 and December 2021 (The covid-19 pandemic period), $R^2 = 0.98$, stepwise model				
Care pathways				
-Discharge home with follow-up at hospital pathways	-	-	-	-
-PAH	0.78	0.89	-0.97 - 2.54	0.381
-DC	-0.55	0.87	-2.26 - 1.16	0.529
Age (years)				
Age < 60	-	-	-	-
Age ≥ 60	-1.25	0.55	-2.33 - -0.16	0.025
BMI (kg/m^2)				
BMI < 25	-	-	-	-
BMI ≥ 25	0.88	0.51	-0.11 - 1.88	0.082
Schemes				
UC	-	-	-	-
SSS	-0.99	0.59	-2.15 - 0.16	0.092
CSMBS	-1.06	0.66	-2.36 - 0.23	0.108
Other	-1.39	1.20	-3.74 - 0.95	0.243

Table 4. 11 Multivariate multilevel mixed-effects linear regression on diastolic blood pressure (Cont.)

Parameters	Coefficient	SE	95%CI	*p*-value
July 2022 and December 2022 (The post-pandemic period), $R^2 = 0.98$, stepwise model				
Care pathways				
-Discharge home with follow-up at hospital pathways	-	-	-	-
-PAH	0.24	1.08	-1.89 - 2.36	0.828
-DC	-0.19	0.86	-1.87 - 1.50	0.828
Sex				
Male	-	-	-	-
Female	0.38	0.41	-1.19 - 0.43	0.354
Age (years)				
Age < 60	-	-	-	-
Age ≥ 60	-0.27	0.41	-1.07 - 0.52	0.503
Comorbidities (diseases)				
≤2	-	-	-	-
> 2	1.05	0.42	0.22 - 1.88	0.013

Table 4. 12 Multivariate multilevel mixed-effects linear regression on fasting blood sugar

Parameters	Coefficient	SE	95%CI	*p*-value
July 2021 and December 2021 (The covid-19 pandemic period), $R^2 = 0.99$, full model				
Care pathways				
-Discharge home with follow-up at hospital	-	-	-	-
pathways	2.33	2.48	-2.54 - 7.20	0.348
-PAH	-0.35	2.50	-5.24 - 4.55	0.890
-DC				
Sex				
Male	-	-	-	-
Female	3.16	1.74	-0.53 - 6.57	0.070
Age (years)				
Age < 60	-	-	-	-
Age ≥ 60	0.12	1.90	-3.60 - 3.84	0.948
BMI group (kg/m^2)				
BMI < 25	-	-	-	-
BMI ≥ 25	3.73	1.79	0.23 - 7.24	0.037
Polypharmacy				
No	-	-	-	-
Yes	-1.81	1.72	-5.18 - 1.56	0.292
Comorbidities (diseases)				
≤2	-	-	-	-
> 2	-2.53	2.04	-6.53 - 1.47	0.215

Table 4. 12 Multivariate multilevel mixed-effects linear regression on fasting blood sugar (Cont.)

Parameters	Coefficient	SE	95%CI	*p*-value
Schemes				
UC	-	-	-	-
SSS	4.27	2.31	-0.27 - 8.80	0.065
CSMBS	2.65	2.18	-1.62 - 6.91	0.224
Other	1.03	4.19	-7.19 - 9.25	0.807
History of COVID-19 infection	-	-	-	-
Yes	-2.80	3.69	-9.99 - 4.48	0.455
No				
July 2022 and December 2022 (The post-pandemic period), $R^2 = 0.99$, full model				
Care pathways				
-Discharge home with follow-up at hospital	-	-	-	-
pathways	-1.69	3.07	-7.72 - 4.33	0.581
-PAH	-0.50	3.14	-6.66 - 5.66	0.873
-DC				
Sex				
Male	-	-	-	-
Female	-1.54	1.63	-4.74 - 1.66	0.345
Age (years)				
Age < 60	-	-	-	-
Age ≥ 60	0.54	1.76	-2.89 - 3.98	0.758

Table 4. 12 Multivariate multilevel mixed-effects linear regression on fasting blood sugar (Cont.)

Parameters	Coefficient	SE	95%CI	*p*-value
BMI group (kg/m^2)				
BMI < 25	-	-	-	-
BMI ≥ 25	1.79	1.67	-1.48 - 5.06	0.283
Polypharmacy				
No	-	-	-	-
Yes	0.73	1.59	-2.40 - 3.85	0.648
Comorbidities (diseases)				
≤2	-	-	-	-
> 2	-5.05	1.85	-8.67 - -1.43	0.006
Schemes				
UC	-	-	-	-
SSS	-3.42	2.18	-7.70 - 0.86	0.118
CSMBS	-1.61	1.96	-5.44 - 2.23	0.412
Other	-0.53	3.96	-8.28 - 7.22	0.894
History of COVID-19 infection	-	-	-	-
Yes	0.63	2.21	-3.69 - 4.96	0.774
No				

Table 4. 13 Multivariate log-linear regression on cost of illness

Parameters	Coefficient	SE	95%CI	*p*-value
July 2021 and December 2021 (The covid-19 pandemic period), $R^2 = 0.81$, full model				
Care pathways				
-Discharge home with follow-up at hospital pathways	-	-	-	-
-PAH	-0.39	0.02	-0.44 - -0.34	<0.001
-DC	-2.73	0.02	-2.78 - -2.69	<0.001
Sex				
Male	-	-	-	-
Female	-0.03	0.01	-0.06 - -0.01	0.019
Age (years)				
Age < 60	-	-	-	-
Age ≥ 60	-0.07	0.02	-0.10 - -0.04	<0.001
BMI (kg/m^2)				
BMI < 25	-	-	-	-
BMI ≥ 25	0.03	0.01	0.01 - 0.06	0.016
Polypharmacy				
No	-	-	-	-
Yes	0.19	0.01	0.16 - 0.21	<0.001
Comorbidities (diseases)				
≤2	-	-	-	-
> 2	0.02	0.02	-0.01 - 0.05	0.259

Table 4. 13 Multivariate log-linear regression on cost of illness (Cont.)

Parameters	Coefficient	SE	95%CI	*p*-value
Schemes				
UC	-	-	-	-
SSS	0.22	0.02	0.19 - 0.25	<0.001
CSMBS	0.28	0.02	0.25 - 0.32	<0.001
Other	0.16	0.03	0.10 - 0.23	<0.001
History of COVID-19 infection	-	-	-	-
Yes	0.02	0.02	-0.03 - 0.07	0.453
No				
July 2022 and December 2022 (The post-pandemic period), $R^2 = 0.80$, full model				
Care pathways				
-Discharge home with follow-up at hospital	-	-	-	-
pathways	-0.51	0.03	-0.57 - -0.44	<0.001
-PAH	-3.26	0.03	-3.31 - -3.21	<0.001
-DC				
Sex				
Male	-	-	-	-
Female	-0.06	0.01	-0.08 - -0.03	<0.001
Age (years)				
Age < 60	-	-	-	-
Age ≥ 60	-0.05	0.01	-0.08 - -0.02	0.001
BMI (kg/m^2)				
BMI < 25	-	-	-	-
BMI ≥ 25	0.001	0.01	-0.03 - 0.02	0.914

Table 4. 13 Multivariate log-linear regression on cost of illness (Cont.)

Parameters	Coefficient	SE	95%CI	*p*-value
Polypharmacy				
No	-	-	-	-
Yes	0.21	0.01	0.19 - 0.24	<0.001
Comorbidities (diseases)				
≤2	-	-	-	-
> 2	0.01	0.01	-0.01 - 0.04	0.38
Schemes				
UC	-	-	-	-
SSS	0.06	0.02	0.02 - 0.09	0.001
CSMBS	0.34	0.02	0.31 - 0.37	<0.001
Other	0.18	0.03	0.12 - 0.25	<0.001
History of COVID-19 infection	-	-	-	-
Yes	0.02	0.02	-0.02 - 0.05	0.304
No				

Table 4. 14 Nationwide estimation of annual number of patients who got policies in Thailand.

Policies	**Prevalence rate in this study**	**Variance of prevalence rate in this study**
July 2021 and December 2021, Overall cases = 305,430 (stable disease) Overall N (DC+PAH) = 54,672		
PAH	0.087	0.0017
DC	0.092	0.0005
July 2022 and December 2022, Overall cases = 318,931 (stable disease) Overall N (DC+PAH) = 30,298		
PAH	0.035	0.0003
DC	0.060	0.0006

Table 4. 15 Nationwide estimation of annual costs of each care pathway from societal perspective

Policies	Conditional cost	Variance of conditional cost	Overall cost (1 million B)	Variance of annual cost (1 million B)	95% CI of variance of annual cost (1 million B)
July 2021 and December 2021					
PAH	Exp(8.04-0.39) = 2100	Exp(0.24) =1.27	55.80	22,408,774.98	-9222 - 9333
DC	Exp(8.04-2.74) = 200	Exp(0.23) =1.26	5.62	59,814.31	-473 - 485

Table 4. 15 Nationwide estimation of annual costs of each care pathway from societal perspective (Cont.)

Policies	Conditional cost	Variance of conditional cost	Overall cost (1 million B)	Variance of annual cost (1 million B)	95% CI of variance of annual cost (1 million B)
July 2022 and December 2022					
PAH	Exp(8.08-0.51) = 1939	Exp(0.03) =1.03	21.64	1,035,393.43	-1972 - 2015
DC	Exp(8.08-3.26) = 124	Exp(0.03) =1.03	2.37	8,472.78	-177 - 182

Table 4. 16 Nationwide estimation of annual costs of each care pathway from government perspective

Policies	Conditional cost	Variance of conditional cost	Overall cost (1 million B)	Variance of annual cost (1 million B)	95% CI of variance of annual cost (1 million B)
July 2021 and December 2021					
PAH	Exp(7.26+0.27) = 1,863	Exp(0.03) =1.03	49.50	17,636,209.81	-8181 - 8280
DC	Exp(7.26+2.08) = 178	Exp(0.03) =1.03	5.00	47,379.77	-422 - 432

Table 4. 16 Nationwide estimation of annual costs of each care pathway from government perspective (Cont.)

Policies	Conditional cost	Variance of conditional cost	Overall cost (1 million B)	Variance of annual cost (1 million B)	95% CI of variance of annual cost (1 million B)
July 2022 and December 2022					
PAH	Exp(7.22+0.16) = 1,604	Exp(0.05) =1.05	17.90	708,530.92	-1632 - 1667
DC	Exp(7.22-2.55) = 107	Exp(0.04) =1.04	2.05	6,309.91	-154 - 158

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Individuals with NCDs were affected by the COVID-19 outbreak because they were required on-going treatment. Healthcare service availability has been diminished globally due to widespread service disruptions in the COVID-19 outbreak. Service disruptions could be either partially or completely. These resulted in a reduction of healthcare visits, hospital admissions, diagnosis, and treatments. Services for hypertension (HT), asthma, diabetes mellitus (DM), and cancer were likely to be extensively disrupted among 168 WHO member countries in the year 2020. Various policies have been adopted by countries to control the spread of COVID-19 and maintain healthcare services up to present. Many large hospitals in Thailand have implemented an array of policies such as the use of telehealth along with pharmacy at home (PAH) program, and telehealth along with deferred care (DC) program since the start of the outbreak. To our knowledge, the studies in Thailand have only evaluated the clinical outcomes of PAH program in HT and DM patients, without assessing economic outcomes. Regarding to the literature searched from several international databases such as the PubMed, the ScienceDirect, the Scopus, and the EBSCO using relevant search terms, there was no published study on evaluation of the telehealth along with pharmacy at home program, as well as telehealth along with deferred care program in NCD patients. Therefore, this study evaluated the care pathways including the DC and PAH program under COVID-19 policies for HT and DM patients both clinical and economic outcomes.

In summary, this study showed that the use of the PAH and DC program resulted in no statistically significant difference in clinical outcomes (SBP, DBP, and FBS), but lower COI than discharge home with follow-up at hospital program in COVID-19 pandemic and post-pandemic period. Nonetheless, the similar inclusion criteria for the PAH and DC programs, which required patients to have stable symptoms and approval from the physician, the duration for receiving these two policies were 5

months and 1 month in PAH and DC, respectively, without worsening in clinical outcomes. This study can support the development of a policy brief on NCDs care in tertiary care hospitals, indicating that PAH and DC program could be safely and cost-effectively implemented under appropriate inclusion criteria and timeframe. These approaches can be employed, if necessary, during the post-pandemic period or under normal circumstances to sustain the policy. In the event of another COVID-19 outbreak or emergency situations, PAH and DC program can be reinstated fully and promptly. It is crucial to prepare an appropriate budget and allocate it efficiently, as the budget utilized during the COVID-19 pandemic for the DC and PAH programs was twice that of the post-pandemic period. The cost incurred for DC and PAH program at tertiary care hospitals nationwide as follows: during the COVID-19 pandemic, the cost of PAH and DC program was 55.8 and 5.62 million THB per year, respectively. In the post-pandemic period, during which the policies are maintained, the cost of PAH and DC program decreased to 21.64 and 2.37 million THB per year, respectively

5.2 Recommendations

5.2.1 For Ministry of public health

This study demonstrated that the care pathways (PAH and DC programs) had no impact on the clinical outcomes (SBP, DBP, and FBS) in both periods. However, these care pathways did have an impact on economic outcomes by helping to reduce costs. These care pathways have specific inclusion criteria and periods. In emergency situations or when it is necessary to implement these care pathways after the COVID-19 pandemic, they can be applied under appropriate conditions and timeframes. However, to ensure their effective implementation during emergencies, it is essential to maintain the use of DC and PAH program in normal circumstances, selecting patients based on necessity.

In cases where long-term use becomes necessary, these care pathways should be combined with other effective care pathways. The PAH and DC program result in several benefits including advancing the healthcare system by improving service delivery, enhancing patient access to healthcare services, reduction in waiting times, alleviation of overcrowding in hospitals, increasing time of healthcare providers

to devote to patients with severe symptoms, and greater opportunities to effectively manage such patients.

5.2.2 For health providers

Since PAH and DC programs are policies that limit face-to-face interactions with patients, communication skills between patients and healthcare providers are crucial. If communication issues occur, they could lead to missed appointments or medication non-adherence, which may eventually result in worsened clinical outcomes. To address this, healthcare providers should implement strategies to enhance communication, such as using telehealth platforms with clear and accessible channels for interaction, providing written and visual instructions for patients, and establishing follow-up mechanisms to ensure understanding and adherence. Additionally, regular training programs for healthcare professionals on effective communication techniques can help minimize misunderstandings and foster better patient-provider relationships. Moreover, health providers should ensure adequate staffing, funding, and resources to deliver services effectively in the event of a pandemic.

5.2.3 For future studies

A long-term study is essential to better evaluate the sustained efficacy and potential drawbacks of the PAH and DC program. The absence of such a study limits the ability to fully assess their long-term impact.

The lack of representation across diverse healthcare settings could affect the generalizability of the findings, as patient populations, resources, and care practices vary significantly between hospital types. Future studies should extend to include primary and secondary hospitals to address this limitation.

If data collection could be conducted in a multicenter setting, there will be a sufficient sample size for all four predefined pathways: Discharge home with follow-up at hospital, PAH, DC, and PAH+DC pathways. This may help reduce selection bias in patient allocation to each pathway from a statistical perspective. The method proposed in this study could be directly applied, reflecting its significant contribution to the literature.

Other important covariates, such as smoking, alcohol consumption, education level, and caregiver status, have been identified in the literature as potentially influential factors. However, the current database did not allow for their inclusion in this analysis. Future research should incorporate these covariates to provide a more comprehensive understanding and enhance the robustness of the findings.

Patient journey will be conduct using qualitative research to explore in-depth insights into patients' decision-making regarding adherence to the policy.

REFERENCES

1. World Health Organization. Noncommunicable diseases: Mortality. 2022 [cited 2022 Dec 11]. Available from: https://www.who.int/data/gho/data/themes/topics/topic-details/GHO/ncd-mortality.
2. United Nations Thailand. Prevention and control of noncommunicable diseases in Thailand 2021 [cited 2024 Sep 15]. 1-90]. Available from: https://thailand.un.org/en/159788-prevention-and-control-noncommunicable-diseases-thailand-%E2%80%93-case-investment.
3. Chang AY, Cullen MR, Harrington RA, Barry M. The impact of novel coronavirus COVID-19 on noncommunicable disease patients and health systems: a review. Journal of Internal Medicine. 2021;289(4):450-62.
4. Moynihan R, Sanders S, Michaleff ZA, Scott AM, Clark J, To EJ, et al. Impact of COVID-19 pandemic on utilisation of healthcare services: a systematic review. BMJ Open. 2021;11(3):e045343.
5. Mansfield KE, Mathur R, Tazare J, Henderson AD, Mulick AR, Carreira H, et al. Indirect acute effects of the COVID-19 pandemic on physical and mental health in the UK: a population-based study. Lancet Digit Health. 2021;3(4):e217-e30.
6. Michalowsky B, Hoffmann W, Bohlken J, Kostev K. Effect of the COVID-19 lockdown on disease recognition and utilisation of healthcare services in the older population in Germany: a cross-sectional study. Age Ageing. 2021;50(2):317-25.
7. Leelahavarong P, Jinathongthai P, Chanthawong S, Wongsalap Y, Kengkla K, Yanpiboon A, et al. An Impact of coronavirus disease 2019 (COVID-19) pandemic on access to healthcare services of elderly in Thailand. Bangkok: Siriraj Health Policy, faculty of medicine, Siriraj hospital; 2022.
8. Hennelly N, Lalor G, Gibney S, Kenny RA, Ward M. A cross-sectional study of the relationship between delayed healthcare utilisation and chronic conditions among older adults during the COVID-19 pandemic in Ireland. HRB Open Research. 2021;4:112.
9. Prvu Bettger J, Thoumi A, Marquevich V, De Groote W, Rizzo Battistella L, Imamura M, et al. COVID-19: maintaining essential rehabilitation services across the care continuum. BMJ Global Health. 2020;5(5):e002670.
10. Kendzerska T, Zhu DT, Gershon AS, Edwards JD, Peixoto C, Robillard R, et al. The Effects of the Health System Response to the COVID-19 Pandemic on Chronic Disease Management: A Narrative Review. Risk Manag Healthc Policy. 2021;14:575-84.
11. World Health Organization Regional Office for Europe. COVID-19 and the disruption of noncommunicable disease services. 2020 [cited 2022 Dec 11]. Available from: https://apps.who.int/iris/bitstream/handle/10665/337813/WHO-EURO-2020-1721-41472-56548-eng.pdf?sequence=1&isAllowed=y.
12. Technical resources, assistance center, and information exchange (TRACIE). COVID-19 healthcare delivery impacts 2021 [cited 2022 Dec 11]. Available from: https://files.asprtracie.hhs.gov/documents/covid-19-healthcare-delivery-impacts-quick-sheet.pdf.

13. Mathieu E, Ritchie H, Rodés-Guirao L, Appel C, Gavrilov D, Giattino C, et al. Policy responses to the coronavirus pandemic 2022 [cited 2022 11 Dec]. Available from: https://ourworldindata.org/policy-responses-covid.
14. Agrawal V, Cantor JH, Sood N, Whaley CM. The impact of the COVID-19 pandemic and policy responses on excess mortality: National Bureau of Economic Research.; 2021 [Available from: https://www.nber.org/system/files/working_papers/w28930/w28930.pdf.
15. Tankul S. Comparison of Hemoglobin A1c levels in Type 2 Diabetic Patients Between Home Delivery of Medication Service and Outpatient Department Service during COVID-19 Pandemic. Journal of Primary Car and Family Medicine. 2022;5(2):123-31.
16. Rattanapan P, Phetcharun P, Suriya S. Development of mail-order pharmacy system for hypertensive patients in era of coronavirus disease 2019 pandemic. Chiangrai medical journal. 2019;12(2):48-66.
17. Ma Y, Zhao C, Zhao Y, Lu J, Jiang H, Cao Y, et al. Telemedicine application in patients with chronic disease: a systematic review and meta-analysis. BMC Medical Informatics and Decision Making. 2022;22(1):1-14.
18. Intan Sabrina M, Defi IR. Telemedicine guidelines in south East Asia—a scoping review. Frontiers in neurology. 2021;11:581649.
19. Bitar H, Alismail S. The role of eHealth, telehealth, and telemedicine for chronic disease patients during COVID-19 pandemic: A rapid systematic review. Digital health. 2021;7:20552076211009396.
20. Shaver J. The state of telehealth before and after the COVID-19 pandemic. Primary Care: Clinics in Office Practice. 2022;49(4):517-30.
21. Sánchez-Gutiérrez C, Gil-García E, Rivera-Sequeiros A, López-Millán JM. Effectiveness of telemedicine psychoeducational interventions for adults with non-oncological chronic disease: A systematic review. Journal of Advanced Nursing. 2022;78(5):1267-80.
22. Leyton C, Zhang C, Rikin S. Evaluation of the effects of the COVID-19 pandemic on electronic consultation use in primary care. Telemedicine and e-Health. 2022;28(1):66-72.
23. Singh T, Ngoh CL, Wong K, Khan BA. Impact of telemedicine on hospitalisation and mortality rates in community-based haemodialysis centres in Singapore during the COVID-19 pandemic. Ann Acad Med Singap. 2020;49(10):756-63.
24. Schmittdiel JA, Karter AJ, Dyer W, Parker M, Uratsu C, Chan J, et al. The comparative effectiveness of mail order pharmacy use vs. local pharmacy use on LDL-C control in new statin users. Journal of general internal medicine. 2011;26:1396-402.
25. Wood Clare BE, Griffiths Beth, Gallagher Rachel, Kendrick Jennifer, Houston Jacqueline, Garner Anna, Babu Chitra and Lee Vincent The impact of the COVID-19 pandemic on HIV care in a large city centre service. HIV Medicine. 2021;22(S2):58.
26. Bailey Angela RS, Malek Ramona, Russell-Hobbs Kate and Sherrard Jackie Evaluation of outcomes from deferred HIV monitoring in the context of the COVID-19 pandemic. HIV Medicine. 2021;22(S2):97.

27. Schwab P, Racsa P, Rascati K, Mourer M, Meah Y, Worley K. A retrospective database study comparing diabetes-related medication adherence and health outcomes for mail-order versus community pharmacy. Journal of Managed Care & Specialty Pharmacy. 2019;25(3):332-40.
28. Wallis CJ, Novara G, Marandino L, Bex A, Kamat AM, Karnes RJ, et al. Risks from deferring treatment for genitourinary cancers: a collaborative review to aid triage and management during the COVID-19 pandemic. European urology. 2020;78(1):29-42.
29. Atmojo JT, Sudaryanto WT, Widiyanto A, Ernawati E, Arradini D. Telemedicine, cost effectiveness, and patients satisfaction: a systematic review. J Health Policy Manag. 2020;5(2):103-7.
30. Wittawassamrankul R. Assessment of mail service pharmacy for outpatient with chronic deseases at Lerdsin Hospital. Bangkok: Mahidol university; 2003.
31. Sumrankong P. Cost-effectiveness analysis of pharmacy mail-order service compared with outpatient department service for schizophrenic patients at Suanprung Hospital, Chiang Mai province. Chiang Mai 2013.
32. Wosik J, Clowse ME, Overton R, Adagarla B, Economou-Zavlanos N, Cavalier J, et al. Impact of the COVID-19 pandemic on patterns of outpatient cardiovascular care. American heart journal. 2021;231:1-5.
33. Soonthorn S, Ngamkham S, Tanglakmankhong K, Wattanakul B, Wanttanakul S. The evaluation of the mailed-order medication system for patients with diabetes mellitus during the COVID-19 pandemic in Thailand. Health Systems Research Institute (HSRI); 2022.
34. Eberle C, Stichling S. Impact of COVID-19 lockdown on glycemic control in patients with type 1 and type 2 diabetes mellitus: a systematic review. Diabetology & metabolic syndrome. 2021;13:1-8.
35. Verma A, Rajput R, Verma S, Balania VK, Jangra B. Impact of lockdown in COVID 19 on glycemic control in patients with type 1 Diabetes Mellitus. Diabetes & Metabolic Syndrome: Clinical Research & Reviews. 2020;14(5):1213-6.
36. Önmez A, Gamsızkan Z, Özdemir Ş, Kesikbaş E, Gökosmanoğlu F, Torun S, et al. The effect of COVID-19 lockdown on glycemic control in patients with type 2 diabetes mellitus in Turkey. Diabetes & Metabolic Syndrome: Clinical Research & Reviews. 2020;14(6):1963-6.
37. Wongmongkol W. Strengthening monitoring system on access to non-COVID-19 health services for Universal Coverage Scheme. 2021.
38. Becevic M, Sheets LR, Wallach E, McEowen A, Bass A, Mutrux ER, et al. Telehealth and telemedicine in Missouri. Missouri Medicine. 2020;117(3):228.
39. Telehealth.NHS.GOV. What is telehealth? 2022 [cited 2022 Dec 12]. Available from: https://telehealth.hhs.gov/patients/understanding-telehealth/.
40. Techatraiphum V, Tharnuraikun A, Krathu W, Chutimaskul W. Telemedicine acceptance framework for the elderly in Thailand. 2016.
41. Omboni S, Padwal RS, Alessa T, Benczúr B, Green BB, Hubbard I, et al. The worldwide impact of telemedicine during COVID-19: current evidence and recommendations for the future. Connect Health. 2022;1:7-35.
42. Patel SY, Mehrotra A, Huskamp HA, Uscher-Pines L, Ganguli I, Barnett ML. Variation in telemedicine use and outpatient care during the COVID-19 pandemic in the United States: study examines variation in total US outpatient visits and

telemedicine use across patient demographics, specialties, and conditions during the COVID-19 pandemic. Health Affairs. 2021;40(2):349-58.
43. Schmittdiel JA, Karter AJ, Dyer WT, Chan J, Duru OK. Safety and effectiveness of mail order pharmacy use in diabetes. Am J Manag Care. 2013;19(11):882-7.
44. Duru OK, Schmittdiel JA, Dyer WT, Parker MM, Uratsu CS, Chan J, et al. Mail-order pharmacy use and adherence to diabetes-related medications. Am J Manag Care. 2010;16(1):33-40.
45. Whitten PS, Mair FS, Haycox A, May CR, Williams TL, Hellmich S. Systematic review of cost effectiveness studies of telemedicine interventions. BMJ. 2002;324(7351):1434-7.
46. Chaomuang N, Dede AJ, Saokaew S, Umnuaypornlert A. Effects of home drug delivery on drug-related problems: preliminary evidence for improved patient outcomes during the COVID-19 pandemic in Thailand. Journal of the American Pharmacists Association. 2022.
47. Charungthanakij N. Outcomes of Glycemic Control in Patients with Type 2 Diabetes
Receiving New Services from Diabetes Clinic, Sai Ngam Hospital
during COVID-19 Pandemic Regional Health Promotion Center 9 Journal. 2021;15(36):129-42.
48. Atherly A, Van den Broek-Altenburg E, Hart V, Gleason K, Carney J. Consumer reported care deferrals due to the COVID-19 pandemic, and the role and potential of telemedicine: cross-sectional analysis. JMIR Public Health and Surveillance. 2020;6(3):e21607.
49. Centers for Disease Control and Prevention. Framework for healthcare systems providing non-COVID-19 Clinical care during the COVID-19 pandemic. 2020 [cited 2023 March 8]. Available from: https://www.agd.org/docs/default-source/advocacy-papers/non-covid-19-care-framework-_-cdc.pdf?sfvrsn=87302c63_0.
50. Adedini SA, Odimegwu C, Imasiku ENS, Ononokpono DN, Ibisomi L. REGIONAL VARIATIONS IN INFANT AND CHILD MORTALITY IN NIGERIA: A MULTILEVEL ANALYSIS. Journal of Biosocial Science. 2015;47(2):165-87.
51. Austin PC. A Tutorial on Multilevel Survival Analysis: Methods, Models and Applications. International Statistical Review. 2017;85(2):185-203.
52. Hox J, Moerbeek M, Van de Schoot R. The basic two-level regression model. Multilevel analysis: Techniques and applications. 2010:11-36.
53. MedCalc. Logistic regression 2023 [cited 2023 Jan 20]. Available from: https://medcalc.org/manual/logistic-regression.php.
54. Stata.com. melogit — Multilevel mixed-effects logistic regression 2024 [cited 2024 Aug 15]. Available from: https://www.stata.com/manuals/memelogit.pdf.
55. Stata.com. meglm — Multilevel mixed-effects generalized linear models 2024 [cited 2024 Aug 15]. Available from: https://www.stata.com/manuals/memeglm.pdf#memeglmRemarksandexamples.
56. Bursac Z, Gauss CH, Williams DK, Hosmer DW. Purposeful selection of variables in logistic regression. Source Code Biol Med. 2008;3:17.
57. Perkin MR, Heap S, Crerar-Gilbert A, Albuquerque W, Haywood S, Avila Z, et al. Deaths in people from Black, Asian and minority ethnic communities from both

COVID-19 and non-COVID causes in the first weeks of the pandemic in London: a hospital case note review. BMJ Open. 2020;10(10):e040638.
58. Bhaskaran K, Bacon S, Evans SJ, Bates CJ, Rentsch CT, MacKenna B, et al. Factors associated with deaths due to COVID-19 versus other causes: population-based cohort analysis of UK primary care data and linked national death registrations within the OpenSAFELY platform. Lancet Reg Health Eur. 2021;6:100109.
59. Kahlberg A, Mascia D, Bellosta R, Attisani L, Pegorer M, Socrate AM, et al. Vascular Surgery During COVID-19 Emergency in Hub Hospitals of Lombardy: Experience on 305 Patients. European Journal of Vascular and Endovascular Surgery. 2021;61(2):306-15.
60. Yeates EO, Grigorian A, Schellenberg M, Owattanapanich N, Barmparas G, Margulies D, et al. Decreased hospital length of stay and intensive care unit admissions for non-COVID blunt trauma patients during the COVID-19 pandemic. Am J Surg. 2022;224(1 Pt A):90-5.
61. Lee J. Delayed or Forgone Care and Virtual Care in a Public Health Crisis Using Nationally Representative Population Data. Telemedicine and e-Health. 2022.
62. VanVoorhis CW, Morgan BL. Understanding power and rules of thumb for determining sample sizes. Tutorials in quantitative methods for psychology. 2007;3(2):43-50.
63. Board of health technology assessment 2021. Health technology assessment guidelines in Thailand2021.
64. Ministry of finance. Public health service fee for treatment reimbursement in goverment hospital Bangkok: Ministry of finance; 2006.
65. Riewpaiboon A. Standard cost lists for health economic evaluation in Thailand. Journal of the Medical Association of Thailand. 2014;97 Suppl 5:S127-34.
66. Trade Policy and Strategy Office. The consumer price index 2025 [cited 2025 July 17]. Available from: http://www.price.moc.go.th/price/cpi/index_new_all.asp.
67. Thai Casemix Centre. Unit cost per disease analysis Phase 1 Year 2. Bangkok2019 [cited 2025 July 17]. 1-75.]. Available from: https://www.tcmc.or.th/%E0%B9%82%E0%B8%84%E0%B8%A3%E0%B8%87%E0%B8%81%E0%B8%B2%E0%B8%A3%E0%B8%A8%E0%B8%B6%E0%B8%81%E0%B8%A9%E0%B8%B2%E0%B8%95%E0%B9%89%E0%B8%99%E0%B8%97%E0%B8%B8%E0%B8%99%E0%B8%A3%E0%B8%B2%E0%B8%A2%E0%B9%82%E0%B8%A3%E0%B8%84%E0%B8%A3%E0%B8%B0%E0%B8%A2%E0%B8%B0%E0%B8%97%E0%B8%B5%E0%B9%881-%E0%B8%9B%E0%B8%B5%E0%B8%87%E0%B8%9A%E0%B8%9B%E0%B8%A3%E0%B8%B0%E0%B8%A1%E0%B8%B2%E0%B8%93-2561-2565-S0071.
68. Phodha T. Epidemiological and economic analysis of antimicrobial resistance in Thailand. Bangkok: Mahidol university; 2018.
69. Phodha T, Riewpaiboon A, Malathum K, Coyte PC. Excess annual economic burdens from nosocomial infections caused by multi-drug resistant bacteria in Thailand. Expert Review of Pharmacoeconomics & Outcomes Research. 2019;19(3):305-12.
70. Koedprakon S. Development of an appointment missed tracking system for patients with diabetes and hypertension at Non Suwan Hospital, Nonsuwan District, Buriram Province, in the year 2560 2017 [cited 2023 July 23]. Available from:

http://www.sangkhahospital.com/sangkha/administrator/modules/mod_download/img/11_261_11_08_2017_16_17_13_SodsriKerdprakon.pdf.
71. Palmer K, Monaco A, Kivipelto M, Onder G, Maggi S, Michel JP, et al. The potential long-term impact of the COVID-19 outbreak on patients with non-communicable diseases in Europe: consequences for healthy ageing. Aging Clin Exp Res. 2020;32(7):1189-94.
72. Duru OK, Schmittdiel JA, Dyer WT, Parker MM, Uratsu CS, Chan J, et al. Mail-order pharmacy use and adherence to diabetes-related medications. The American journal of managed care. 2010;16(1):33.
73. Xu X, Wong SC, Zhu F, Pei X, Huang H, Liu Y. A Heckman selection model for the safety analysis of signalized intersections. PLoS One. 2017;12(7):e0181544.
74. Ostertagová E. Modelling using Polynomial Regression. Procedia Engineering. 2012;48:500-6.
75. Thorsen K, Søreide JA, Søreide K. What Is the Best Predictor of Mortality in Perforated Peptic Ulcer Disease? A Population-Based, Multivariable Regression Analysis Including Three Clinical Scoring Systems. Journal of Gastrointestinal Surgery. 2014;18(7):1261-8.
76. American Diabetes Association Professional Practice Committee. Introduction and Methodology: Standards of Care in Diabetes—2024. Diabetes Care. 2023;47(Supplement_1):S1-S4.
77. Kreutz R, Brunström M, Burnier M, Grassi G, Januszewicz A, Muiesan ML, et al. 2024 European Society of Hypertension clinical practice guidelines for the management of arterial hypertension. European Journal of Internal Medicine. 2024;126:1-15.
78. Health Data Center. Standard report 2024 [cited 2024 Sep 15]. Available from: https://hdc.moph.go.th/center/public/kpi/1/2025.
79. Strand LM, Morley PC, Cipolle RJ, Ramsey R, Lamsam GD. Drug-related problems: their structure and function. Dicp. 1990;24(11):1093-7.

APPENDICES

APPENDIX A
TERMS AND DEFINITIONS

- Clinical outcomes are missed appointment, failure to receive drug, hospitalization, and surrogate markers
- Economic outcomes are cost of illness and cost of health service.
- Surrogate markers include BP and FBS
- Normal-range surrogate marker (good control) is BP < 140/80 mmHg (77) and FBS < 130 mg/dL (76).
- Care pathways are mutually exclusive and exhaustive four care pathways for index NCD patients in OPD including telehealth along with deferred care program (DC), telehealth along with pharmacy at home program (PAH), the telehealth along with deferred care and telehealth along with the pharmacy at home program (DC + PAH), and discharge home with follow-up at the hospital.
- The telehealth along with deferred care program (DC) allows patients to pause or postpone an appointment. The process is subject to the approval of either a healthcare provider or the patient themselves. The inclusion criteria are patient with stable symptom and sufficient medicine at home. In the case of hospital visits that have been deferred at Saraburi hospital, these appointments were not examined by a physician and were marked with the letter "A" in front of the next visit number.
- The telehealth along with pharmacy at home program (PAH) is associated with the delivery of medicines by post. The characteristics of the patient and medicines are assessed and approved by healthcare providers. The inclusion criteria are a patient with stable symptom, no complications, and suitable drug for postal.
- The term "DC+PAH" means that people can have continuous visits to both "DC" and "PAH," or they can visit "PAH" and "DC" alternatively. These two types of visits were added together or counted as one.
- Non-communicable diseases (NCDs), including HT and DM, are typically associated with the high-rate disruption and the extensive implementation of policies.
- Hospitalizations are admissions, ED visits, and pre-visits due to complications.

- A missed appointment is defined as a scheduled visit that is not attended by the patient without prior notification. At Saraburi Hospital protocol, when an appointment is missed, the patient is not examined by a physician. No medical service is provided during that hospital visit, and it is recorded as an empty visit. For the next appointment, the visit number is not assigned an "A" prefix.
- Failure to receive drug means that the patient does not obtain or use the drug that was prescribed (79). This could be attributed to various factors, including non-adherence, poor administration technique, missed doses resulting from medication errors, sub-standard drugs, unavailability of prescribed medications, and patient's inability to afford the medication. In this study, failure to receive drug refers specifically to missed doses due to medication errors and patient's errors. There were various reasons for patients' errors in not taking medication. Failure to receive medication in the context of patients' errors in this study refers to patients who do not receive their prescribed medication on the scheduled day and do not contact the hospital to obtain medication. It also includes patients who have the medication but stop taking it. However, failure to receive drug does not encompass patients who have the medication but take it inconsistently. Failure to receive medication could be identified through the documentation recorded by healthcare providers.
- Polypharmacy is a term used to describe patients who take multiple medications. According to the definitions applied in this study, polypharmacy typically involves the use of more than five medications (8).
- Multicriteria refers to the possibility that some patients could be classified into more than one disease group, resulting in duplicate counts across groups.

APPENDIX B
CASE RECORD FORM

Index case: Stable NCD patients (HT and DM) from July 01, 2021 and December 31, 2021, and July 01, 2022 to December 31, 2022.

Diseases	**ICD-10 (7)**
Hypertension	I10
Diabetes	E119, E129, E139, E149

1. At each OPD visit
1.1 Demographic data
Sequence number
Age (year)
Sex □ male □ female
Medical benefit scheme □ UC □ CSMBS □ SSS □ Other
BMI
1.2 Clinical data
Principal diagnosis (PDX)
Secondary diagnosis (SDX)
Number of drug items
BP
FBS
Failure to receive drug □ yes □ no
1.3 Service/resource utilization
Visit date
Follow-up date
Telehealth along with deferred care □ yes □ no
Telehealth along with pharmacy at home □ yes □ no
Missed appointment □ yes □ no

1. At each OPD visit
1.3 Service/resource utilization
Anesthetic charge
Diagnostic charge
Dietary charge
General charge
Laboratory charge
Supply charge
X-ray charge
Procedure charge
Rehabilitation charge
Drug charge
2. At each IPD visit or ED visit
2.1 Clinical data
Principal diagnosis (PDX)
Secondary diagnosis (SDX)
2.2 Service/resource utilization
Admit date
Discharge date
Anesthetic charge
Diagnostic charge
Dietary charge
General charge
Laboratory charge
Supply charge
X-ray charge
Procedure charge
Rehabilitation charge
Drug charge

APPENDIX C
ADDITIONAL RESULTS

Table 1 Selection bias assessment between discharge home with follow-up at hospital and PAH/DC pathways in hypertension patient between July 2021 and December 2021

Parameters	Probit regression				Heckman selection regression			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
Sex (Ref=male)	0.05	0.06	-0.06 - 0.17	0.368	-1.46	0.75	-2.94 - -0.01	0.051
age (Ref <60)	-0.02	0.07	-0.15 - 0.10	0.717	0.65	0.34	-0.01 - 1.31	0.055
BMI (Ref <25)	0.05	0.06	-0.07 - 0.16	0.437	-1.28	0.65	-2.56 - 0.00	0.050
MED (Ref <5)	-0.03	0.06	-0.14 - 0.09	0.640	0.75	0.39	-0.01 - 1.52	0.052
Comorbidities (Ref ≤2)	0.24	0.06	0.12 - 0.36	<0.001	-6.69	3.41	-13.39 - -0.00	0.050

Table 1 Selection bias assessment between discharge home with follow-up at hospital and PAH/DC pathways in hypertension patient between July 2021 and December 2021 (Cont.)

Parameters	Probit regression				Heckman selection regression			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
Schemes								
UC	-	-	-	-	-	-	-	-
SSS	0.17	0.07	0.04 - 0.32	0.012	-4.92	2.51	-9.85 - 0.01	0.050
CSMBS	0.29	0.07	0.15 - 0.43	<0.001	-8.00	4.09	-16.02 - 0.02	0.050
Other	0.10	0.13	-0.16 - 0.36	0.451	-2.80	1.43	-5.62 - 0.02	0.837
Covid (Ref=yes)	0.02	0.10	-0.18 - 0.22	0.851	-0.55	0.30	-1.15 – 0.04	0.070
Inverse mill ratio					-35.95	17.72	-70.68 – -1.22	0.047
Log likelihood	-1523.30				-1521.13			
R-square	0.012				0.013			

Table 2 Selection bias assessment between PAH and discharge home with follow-up at hospital/DC pathways in hypertension patient between July 2021 and December 2021

Parameters	Probit regression				Heckman selection regression			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
Sex (Ref=male)	-0.16	0.07	-0.30 - -0.03	0.019	0.15	0.20	-2.94 - -0.55	0.445
age (Ref <60)	-0.12	0.07	-0.27 - 0.03	0.111	0.11	0.16	-0.19 - 0.42	0.470
BMI (Ref <25)	-0.012	0.07	-0.15 - 0.12	0.862	0.02	0.07	-0.12 - 0.15	0.829
MED (Ref <5)	0.06	0.07	-0.08 - 0.20	0.384	-0.06	0.09	-0.25 - 0.13	0.542
Comorbidities(Ref ≤2)	0.18	0.06	0.05 - 0.32	0.008	-0.19	0.23	-0.64 - 0.26	0.408
Schemes								
UC	-	-	-	-	-	-	-	-
SSS	-0.32	0.08	0.48 - -0.15	<0.001	0.26	0.35	-0.42 - 0.94	0.458
CSMBS	-0.46	0.08	-0.63 - -0.29	<0.001	0.46	0.55	-0.62 – 1.54	0.403
Other	-0.18	0.17	-0.51 - 0.15	0.286	0.13	0.25	-0.36 - 0.02	0.612

Table 2 Selection bias assessment between PAH and discharge home with follow-up at hospital/DC pathways in hypertension patient between July 2021 and December 2021 (Cont.)

Parameters	Probit regression				Heckman selection regression			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
Covid (Ref=yes)	-0.05	0.12	-0.29 - 0.18	0.668	-0.05	0.13	-0.21 – 0.32	0.680
Inverse mill ratio					-7.73	4.53	-16.61 – 1.16	0.088
Log likelihood	-920.84				-919.30			
R-square	0.029				0.030			

Table 3 Selection bias assessment between DC and discharge home with follow-up at hospital/PAH pathways in hypertension patient between July 2021 and December 2021

Parameters	Probit regression				Heckman selection regression			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
Sex (Ref=male)	0.08	0.07	-0.07 - 0.22	0.299	0.04	0.17	-0.29 - -0.37	0.809
age (Ref <60)	0.14	0.08	-0.02 - 0.30	0.079	0.08	0.29	-0.51 - 0.66	0.796
BMI (Ref <25)	-0.05	0.07	-0.19 - 0.09	0.523	0.03	0.12	-0.26 - 0.21	0.824
MED (Ref <5)	-0.02	0.07	-0.15 - 0.11	0.773	-0.01	0.07	-0.16 - 0.14	0.896
Comorbidities (Ref ≤2)	-0.66	0.09	-0.84 - -0.48	<0.001	-0.42	1.06	-2.49 - 1.66	0.693
Schemes								
UC	-	-	-	-	-	-	-	-
SSS	0.01	0.09	-0.16 - 0.19	0.882	0.006	0.09	-0.18 - 0.19	0.947
CSMBS	-0.02	0.09	-0.20 - 0.16	0.792	-0.013	0.11	-0.22 – 0.19	0.902
Other	-0.01	0.16	-0.32 - 0.29	0.942	-0.006	0.16	-0.31 - 0.30	0.969

Table 3 Selection bias assessment between DC and discharge home with follow-up at hospital/PAH pathways in hypertension patient between July 2021 and December 2021 (Cont.)

Parameters	Probit regression				Heckman selection regression			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
Covid (Ref=yes)	-0.02	0.14	-0.25 - 0.30	0.879	0.01	0.15	-0.27 – 0.29	0.928
Inverse mill ratio					-1.63	7.11	-15.57 – 12.31	0.819
Log likelihood	-967.18				-967.15			
R-square	0.041				0.041			

Table 4 Selection bias assessment between discharge home with follow-up at hospital and PAH/DC pathways in diabetes patient between July 2021 and December 2021

Parameters	Probit regression				Heckman selection regression			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
Sex (Ref=male)	0.06	0.07	-0.09 - 0.21	0.415	-0.35	0.51	-1.36 - 0.66	0.496
age (Ref <60)	0.08	0.08	-0.08 - 0.24	0.309	-0.47	0.69	-1.82 - 0.88	0.494
BMI (Ref <25)	0.02	0.07	-0.12 - 0.17	0.759	-0.13	0.20	-0.53 - 0.27	0.518
MED (Ref <5)	-0.26	0.07	-0.39 - -0.12	<0.001	1.48	2.15	-2.74 - 5.70	0.491
Comorbidities (Ref ≤2)	0.19	0.08	0.03 - 0.35	0.022	-1.11	1.61	-4.25 - 2.04	0.491
Schemes								
UC	-	-	-	-	-	-	-	-
SSS	0.08	0.09	-0.11 - 0.27	0.396	-0.48	0.69	-1.85 - 0.89	0.496
CSMBS	0.24	0.09	0.07 - 0.42	0.007	-1.37	1.99	-5.29 – 2.54	0.492
Other	0.14	0.17	-0.21 - 0.49	0.427	-0.79	0.18	-3.11 - 1.51	0.497

Table 4 Selection bias assessment between discharge home with follow-up at hospital and PAH/DC pathways in diabetes patient between July 2021 and December 2021 (Cont.)

Parameters	Probit regression				Heckman selection regression			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
Covid (Ref=yes)	-0.19	0.15	-0.48 - 0.10	0.209	1.05	1.55	-1.97 – 4.09	0.495
Inverse mill ratio					-9.05	11.19	-30.97 – 12.87	0.418
Log likelihood	-1025.44				-1025.10			
R-square	0.015				0.015			

Table 5 Selection bias assessment between PAH and discharge home with follow-up at hospital/DC pathways in diabetes patient between July 2021 and December 2021

Parameters	Probit regression				Heckman selection regression			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
Sex (Ref=male)	-0.18	0.09	-0.36 - -0.02	0.031	-0.08	0.19	-0.45 - 0.30	0.690
age (Ref <60)	-0.13	0.09	-0.30 - 0.47	0.15	-0.05	0.15	-0.34 - 0.24	0.724
BMI (Ref <25)	0.06	0.08	-0.11 - 0.22	0.480	0.26	0.09	-0.17 - 0.22	0.793
MED (Ref <5)	0.29	0.08	0.13 - 0.45	<0.001	0.12	0.29	-0.45 - 0.68	0.491
Comorbidities (Ref ≤2)	0.25	0.09	0.08 - 0.43	0.004	0.09	0.27	-0.44 - 0.62	0.740
Schemes								
UC	-	-	-	-	-	-	-	-
SSS	-0.26	0.11	-0.47 - -0.05	0.016	-0.12	0.25	-0.60 - 0.37	0.643
CSMBS	-0.48	0.10	-0.67 - 0.42	<0.001	-0.18	0.47	-1.11 – 0.74	0.698
Other	-0.21	0.21	-0.62 - 0.49	0.303	-0.09	0.27	-0.63 - 0.44	0.728

Table 5 Selection bias assessment between PAH and discharge home with follow-up at hospital/DC pathways in diabetes patient between July 2021 and December 2021 (Cont.)

Parameters	Probit regression				Heckman selection regression			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
Covid (Ref=yes)	0.19	0.17	-0.32 - 0.35	0.910	0.00	0.18	-0.34 – 0.35	0.987
Inverse mill ratio					-1.76	2.78	-7.21 – 3.68	0.526
Log likelihood	-656.09				-655.89			
R-square	0.043				0.043			

Table 6 Selection bias assessment between DC and discharge home with follow-up at hospital/PAH pathways in diabetes patient between July 2021 and December 2021

Parameters	Probit regression				Heckman selection regression			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
Sex (Ref=male)	0.06	0.08	-0.09 - 0.26	0.342	-0.18	0.16	-0.50 - 0.14	0.273
age (Ref <60)	-0.01	0.09	-0.20 - 0.18	0.894	0.03	0.09	-1.16 - 0.22	0.748
BMI (Ref <25)	-0.08	0.09	-0.26 - 0.09	0.381	0.17	0.16	-0.14 - 0.48	0.292
MED (Ref <5)	0.11	0.08	-0.06 - -0.27	0.209	-0.22	0.19	-0.61 - 0.17	0.266
Comorbidities (Ref ≤2)	-0.64	0.12	-0.87 - -0.41	<0.001	0.98	0.89	-0.76 - 2.74	0.269
Schemes								
UC	-	-	-	-	-	-	-	-
SSS	0.11	0.12	-0.12 - 0.34	0.355	-0.22	0.22	-0.64 - 0.20	0.305
CSMBS	0.09	0.11	-0.12 - 0.31	0.373	-0.21	0.19	-0.59 - 0.17	0.277
Other	-0.03	0.21	-0.44 - 0.37	0.869	0.08	0.21	-0.38 - 0.51	0.697

Table 6 Selection bias assessment between DC and discharge home with follow-up at hospital/PAH pathways in diabetes patient between July 2021 and December 2021 (Cont.)

Parameters	Probit regression				Heckman selection regression			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
Covid (Ref=yes)	0.27	0.17	-0.08 - 0.61	0.126	0.55	0.45	-1.44 – 0.33	0.219
Inverse mill ratio					-8.46	4.61	-17.49 – 0.57	0.066
Log likelihood	-709.22				-707.78			
R-square	0.035				0.036			

Table 7 Selection bias assessment between discharge home with follow-up at hospital and PAH/DC pathways in hypertension patient between July 2022 and December 2022

Parameters	Probit regression				Heckman selection regression			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
Sex (Ref=male)	-0.08	0.07	-0.21 - 0.04	0.196	-0.35	0.56	-1.44 - 0.74	0.529
age (Ref <60)	0.05	0.07	-0.09 - 0.19	0.499	0.20	0.33	-0.45 - 0.85	0.543
BMI (Ref <25)	0.06	0.07	-0.07 - 0.19	0.342	0.26	0.42	-0.57 - 1.09	0.537
MED (Ref <5)	0.04	0.06	-0.08 - 0.17	0.510	0.17	0.28	-0.37 - 0.71	0.532
Comorbidities (Ref ≤2)	0.57	0.07	0.42 - 0.71	<0.001	2.40	3.80	-5.05 - 9.86	0.528
Schemes								
UC	-	-	-	-	-	-	-	-
SSS	-0.15	0.09	-0.33 - 0.03	0.110	-0.63	1.00	-2.60 - 1.34	0.533
CSMBS	0.25	0.08	0.10 - 0.40	0.001	1.03	1.63	-2.15 - 4.22	0.526
Other	0.05	0.15	-0.25 - 0.34	0.757	0.19	0.34	-0.47 - 0.85	0.567

Table 7 Selection bias assessment between discharge home with follow-up at hospital and PAH/DC pathways in hypertension patient between July 2022 and December 2022 (Cont.)

Parameters	Probit regression				Heckman selection regression			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
Covid (Ref=yes)	-0.11	0.09	-0.28 - 0.07	0.252	-0.42	0.68	-1.75 – 0.91	0.534
Inverse mill ratio					3.79	7.88	-11.65 – 19.24	0.630
Log likelihood	-1220.78				-1220.65			
R-square	0.053				0.053			

Table 8 Selection bias assessment between PAH and discharge home with follow-up at hospital/DC pathways in hypertension patient between July 2022 and December 2022

Parameters	Probit regression				Heckman selection regression			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
Sex (Ref=male)	-0.11	0.09	-0.29 - 0.07	0.227	-0.08	0.11	-0.29 - 0.13	0.449
age (Ref <60)	-0.13	0.10	-0.33 - 0.07	0.196	-0.09	0.12	-0.33 - 0.14	0.422
BMI (Ref <25)	-0.12	0.09	-0.29 - 0.05	0.167	-0.09	0.10	-0.29 - 0.11	0.377
MED (Ref <5)	-0.17	0.09	-0.34 - -0.00	0.048	-0.13	0.12	-0.37 - 0.12	0.301
Comorbidities (Ref ≤2)	-0.38	0.10	-0.58 - 0.71	-0.19	-0.31	0.18	-0.66 - 0.05	0.088
Schemes								
UC	-	-	-	-	-	-	-	-
SSS	0.13	0.15	-0.16 - 0.41	0.379	0.12	0.15	-0.16 - 0.41	0.396
CSMBS	-0.48	0.09	-0.66 - -0.29	<0.001	-0.33	0.27	-0.87 - 0.20	0.224
Other	0.26	0.25	-0.26 - 0.71	0.363	0.18	0.25	-0.32 - 0.68	0.477

Table 8 Selection bias assessment between PAH and discharge home with follow-up at hospital/DC pathways in hypertension patient between July 2022 and December 2022 (Cont.)

Parameters	Probit regression				Heckman selection regression			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
Covid (Ref=yes)	-0.03	0.13	-0.29 - 0.22	0.788	-0.02	0.13	-0.28 – 0.23	0.848
Inverse mill ratio					-1.49	2.73	-6.84 – 3.86	0.586
Log likelihood	-571.69				-571.55			
R-square	0.079				0.079			

Table 9 Selection bias assessment between DC and discharge home with follow-up at hospital/PAH pathways in hypertension patient between July 2022 and December 2022

Parameters	Probit regression				Heckman selection regression			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
Sex (Ref=male)	0.17	0.07	0.03 - 0.32	0.016	0.14	0.17	-0.19 - 0.48	0.396
age (Ref <60)	0.02	0.08	-0.14 - 0.18	0.815	0.02	0.08	-0.14 - 0.18	0.851
BMI (Ref <25)	-0.02	0.07	-0.16 - 0.13	0.834	-0.01	0.07	-0.16 - 0.13	0.863
MED (Ref <5)	0.04	0.07	-0.09 - 0.18	0.543	0.04	0.08	-0.12 - 0.19	0.653
Comorbidities (Ref ≤2)	-0.56	0.09	-0.73 - -0.39	<0.001	-0.48	0.45	-1.35 - 0.39	0.279
Schemes								
UC	-	-	-	-	-	-	-	-
SSS	0.16	0.10	-0.04 - 0.36	0.111	0.14	0.15	-0.16 - 0.43	0.365
CSMBS	-0.01	0.09	-0.19 - 0.17	0.899	-0.01	0.09	-0.19 - 0.17	0.921
Other	-0.14	0.16	-0.45 - 0.18	0.402	0.11	0.24	-0.57 - 0.35	0.646

Table 9 Selection bias assessment between DC and discharge home with follow-up at hospital/PAH pathways in hypertension patient between July 2022 and December 2022 (Cont.)

Parameters	Probit regression				Heckman selection regression			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
Covid (Ref=yes)	0.15	0.09	-0.04 - 0.34	0.117	0.12	0.16	-0.19 – 0.44	0.440
Inverse mill ratio					-0.75	4.18	-8.94 – 7.45	0.858
Log likelihood	-896.09				-896.08			
R-square	0.040				0.040			

Table 10 Selection bias assessment between discharge home with follow-up at hospital and DC/PAH pathways in diabetes patient between July 2022 and December 2022

Parameters	Probit regression				Heckman selection regression			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
Sex (Ref=male)	-0.09	0.08	-0.25 - 0.07	0.251	-0.003	0.47	-0.92 - 0.91	0.994
age (Ref <60)	0.06	0.09	-0.11 - 0.23	0.484	0.003	0.32	-0.63 - 0.63	0.993
BMI (Ref <25)	0.05	0.08	-0.11 - 0.21	0.508	0.002	0.28	-0.55 - 0.55	0.993
MED (Ref <5)	-0.14	0.08	-0.29 - 0.01	0.06	-0.01	0.69	-1.36 - 1.34	0.992
Comorbidities (Ref ≤2)	0.61	0.09	0.43 - 0.79	<0.001	0.01	3.08	-6.03 - 6.05	0.998
Schemes								
UC	-	-	-	-	-	-	-	-
SSS	-0.17	0.12	-0.39 - 0.05	0.134	-0.002	0.89	-1.74 - 1.74	0.998
CSMBS	0.29	0.09	0.12 - 0.48	0.001	0.02	1.43	-2.78 - 2.82	0.989
Other	0.05	0.18	-0.31 - 0.39	0.802	0.002	0.28	-0.55 - 0.55	0.994

Table 10 Selection bias assessment between discharge home with follow-up at hospital and DC/PAH pathways in diabetes patient between July 2022 and December 2022 (Cont.)

Parameters	Probit regression				Heckman selection regression			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
Covid (Ref=yes)	-0.11	0.11	-0.32 - 0.11	0.324	-0.005	0.54	-1.06 – 1.05	0.993
Inverse mill ratio					-1.21	6.21	-13.39 – 10.96	0.845
Log likelihood	-860.69				-860.67			
R-square	0.051				0.051			

Table 11 Selection bias assessment between PAH and discharge home with follow-up at hospital/DC pathways in diabetes patient between July 2022 and December 2022

Parameters	Probit regression				Heckman selection regression			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
Sex (Ref=male)	-0.10	0.11	-0.33 - 0.12	0.365	-0.04	0.13	-0.29 - 0.21	0.751
age (Ref <60)	0.15	0.13	-0.39 - 0.10	0.247	-0.06	0.15	-0.36 - 0.25	0.713
BMI (Ref <25)	-0.18	0.11	-0.39 - 0.04	0.102	-0.07	0.14	-0.34 - 0.19	0.603
MED (Ref <5)	-0.09	0.11	-0.30 - 0.12	0.387	-0.04	0.12	-0.27 - 0.19	0.728
Comorbidities (Ref ≤2)	0.65	0.15	0.95 - -0.36	<0.001	-0.38	0.30	-0.97 - 0.21	0.209
Schemes								
UC	-	-	-	-	-	-	-	-
SSS	0.14	0.19	-0.23 - 0.51	0.450	0.12	0.19	-0.25 - 0.49	0.524
CSMBS	-0.56	0.11	-0.78 - -0.34	<0.001	-0.18	0.35	-0.86 - 0.51	0.609
Other	0.16	0.28	-0.38 - 0.71	0.559	0.09	0.28	-0.46 - 0.64	0.749

Table 11 Selection bias assessment between PAH and discharge home with follow-up at hospital/DC pathways in diabetes patient between July 2022 and December 2022 (Cont.)

Parameters	Probit regression				Heckman selection regression			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
Covid (Ref=yes)	-0.01	0.16	-0.32 - 0.29	0.937	-0.002	0.15	-0.31 – 0.30	0.989
Inverse mill ratio					-2.45	2.22	-6.79 – 1.89	0.268
Log likelihood	-415.81				-415.30			
R-square	0.096				0.097			

Table 12 Selection bias assessment between DC and discharge home with follow-up at hospital/PAH pathways in diabetes patient between July 2022 and December 2022

Parameters	Probit regression				Heckman selection regression			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
Sex (Ref=male)	0.17	0.09	0.001 - 0.35	0.05	0.29	0.22	-0.13 - 0.72	0.174
age (Ref <60)	0.02	0.09	-0.17 - 0.19	0.86	0.28	0.09	-0.16 - 0.22	0.773
BMI (Ref <25)	0.03	0.09	-0.15 - 0.20	0.760	0.05	0.09	-0.14 - 0.24	0.622
MED (Ref <5)	0.22	0.08	0.06 - 0.38	0.007	0.38	0.28	-0.16 - 0.93	0.171
Comorbidities (Ref ≤2)	-0.46	0.10	-0.66 - -0.26	<0.001	-0.75	0.50	-1.74 - 0.24	0.137
Schemes								
UC	-	-	-	-	-	-	-	-
SSS	0.18	0.12	-0.05 - 0.41	0.132	0.30	0.23	-0.14 - 0.74	0.181
CSMBS	0.002	0.11	-0.21 - 0.21	0.984	0.001	0.11	-0.21 - 0.21	0.990
Other	-0.11	0.19	-0.48 - 0.26	0.555	-0.20	0.25	-0.69 - 0.29	0.415

Table 12 Selection bias assessment between DC and discharge home with follow-up at hospital/PAH pathways in diabetes patient between July 2022 and December 2022 (Cont.)

Parameters	Probit regression				Heckman selection regression			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
Covid (Ref=yes)	0.14	0.11	-0.08 - 0.36	0.221	0.19	0.15	-0.15 – 0.63	0.224
Inverse mill ratio					2.26	3.87	-5.32 – 9.84	0.560
Log likelihood	-663.97				-663.82			
R-square	0.031				0.031			

Table 13 Factors affecting difference systolic BP between July 2021 and December 2021 by difference methods of model building

Parameters	Full model				Stepwise model			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
Care pathways								
-Discharge home with follow-up at hospital pathways	-	-	-	-	-	-	-	-
-PAH	-1.23	1.11	-3.41 - 0.96	0.269	-1.23	1.11	-3.41 - 0.95	0.272
-DC	0.27	1.13	-1.95 - 2.50	0.809	0.27	1.13	-1.95 - 2.50	0.811
Sex (Ref=male)	0.25	0.62	-1.20 - 1.25	0.969	0.23	0.62	-1.20 - 1.24	0.970
age (Ref <60)	1.94	0.70	0.56 - 3.31	0.006	1.94	0.70	0.57 - 3.33	0.006
BMI (Ref <25)	1.28	0.64	0.33 - 2.53	0.044	1.29	0.64	0.04 - 2.54	0.043
MED (Ref <5)	0.65	0.64	-0.60 - 1.90	0.306	0.65	0.64	-0.61 - 1.90	0.312

Table 13 Factors affecting difference systolic BP between July 2021 and December 2021 by difference methods of model building (Cont.)

Parameters	Full model				Stepwise model			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
Comorbidities (Ref ≤2)	-1.87	0.69	-3.22 - -0.52	0.007	-1.79	0.68	-3.12 - -0.47	0.008
Schemes								
UC	-	-	-	-	-	-	-	-
SSS	-0.70	0.77	-2.20 - 0.81	0.366	-0.69	0.77	-2.20 - 0.81	0.367
CSMBS	-0.16	0.83	-1.78 - 1.46	0.846	-0.16	0.83	-1.78 - 1.46	0.845
Other	0.80	1.50	-2.14 - 3.74	0.594	0.83	1.50	-2.11 - 3.77	0.580
Covid (Ref=yes)	0.66	1.13	-1.55 - 2.87	0.556	-	-	-	-
AIC	29684.88				29691.23			
BIC	29758.69				29783.49			

Table 13 Factors affecting difference systolic BP between July 2021 and December 2021 by difference methods of model building (Cont.)

Parameters	Full model				Stepwise model			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
Log likelihood	-14830.44				-14830.61			
RMSE	17.47				17.47			
R-square	0.16				0.80			

Table 14 Factors affecting difference diastolic BP between July 2021 and December 2021 by difference methods of model building

Parameters	Full model				Stepwise model			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
Care pathways								
-Discharge home with follow-up at hospital pathways	-	-	-	-	-	-	-	-
-PAH	0.73	0.90	-1.02 - 2.49	0.412	0.78	0.89	-0.97 - 2.54	0.381
-DC	-0.45	0.88	-2.18 - 1.27	0.605	-0.55	0.87	-2.26 - 1.16	0.529
Sex (Ref=male)	0.20	0.50	-0.77 - 1.18	0.685	-	-	-	-
age (Ref <60)	-1.21	0.56	-2.31 - -0.11	0.031	-1.25	0.55	-2.33 - -0.16	0.025
BMI (Ref <25)	0.89	0.51	-0.11 - 1.89	0.081	0.88	0.51	-0.11 - 1.88	0.082
MED (Ref <5)	-0.15	0.51	-1.15 - 0.85	0.769	-	-	-	-
Comorbidities (Ref ≤2)	-0.43	0.55	-1.51 - 0.65	0.433	-	-	-	-

Table 14 Factors affecting difference diastolic BP between July 2021 and December 2021 by difference methods of model building (Cont.)

Parameters	Full model				Stepwise model			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
Schemes								
UC	-	-	-	-	-	-	-	-
SSS	-1.11	0.62	-2.31 - 0.10	0.072	-0.99	0.59	-2.15 - 0.16	0.092
CSMBS	-1.05	0.66	-2.35 - 0.24	0.112	-1.06	0.66	-2.36 - 0.23	0.108
Other	-1.34	1.20	-3.70 - 1.01	0.264	-1.39	1.20	-3.74 - 0.95	0.243
Covid (Ref=yes)	0.52	0.90	-1.25 - 2.29	0.568	-	-	-	-
AIC	28144.14				28145.3			
BIC	28217.95				28219.11			
Log likelihood	-14060.07				-14060.65			

Table 14 Factors affecting difference diastolic BP between July 2021 and December 2021 by difference methods of model building (Cont.)

Parameters	Full model				Stepwise model			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
RMSE	13.98				13.99			
R-square	-8.49				0.98			

Table 15 Factors affecting difference diastolic BP between July 2022 and December 2022 by difference methods of model building

Parameters	Full model				Stepwise model			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
Care pathways								
-Discharge home with follow-up at hospital pathways	-	-	-	-	-	-	-	-
-PAH	0.31	1.09	-1.83 - 2.44	0.779	0.24	1.08	-1.89 - 2.36	0.828
-DC	-0.20	0.86	-1.88 - 1.49	0.819	-0.19	0.86	-1.87 - 1.50	0.828
Sex (Ref=male)	-0.39	0.42	-1.20 - 0.43	0.354	0.38	0.41	-1.19 - 0.43	0.354
age (Ref <60)	-0.24	0.46	-1.13 - 0.66	0.607	-0.27	0.41	-1.07 - 0.52	0.503
BMI (Ref <25)	-0.22	0.43	-1.05 - 0.62	0.608	-	-	-	-
MED (Ref <5)	0.14	0.42	-0.69 - 0.97	0.743	-	-	-	-
Comorbidities(Ref ≤2)	1.07	0.44	0.20 - 1.94	0.016	1.05	0.42	0.22 - 1.88	0.013

Table 15 Factors affecting difference diastolic BP between July 2022 and December 2022 by difference methods of model building (Cont.)

Parameters	Full model				Stepwise model			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
Schemes								
UC	-	-	-	-	-	-	-	-
SSS	0.03	0.54	-1.03 - 1.09	0.960	-	-	-	-
CSMBS	-0.28	0.53	-1.33 - 0.76	0.595	-	-	-	-
Other	-0.03	1.05	-2.09 - 2.02	0.976	-	-	-	-
Covid (Ref=yes)	-0.56	0.55	-1.64 - 0.51	0.305	-	-	-	-
AIC	32525.77				28145.3			
BIC	32601.62				28219.11			
Log likelihood	-16250.89				-14060.65			

Table 15 Factors affecting difference diastolic BP between July 2022 and December 2022 by difference methods of model building (Cont.)

Parameters	Full model				Stepwise model			
	Coefficient	SE	95%CI	*p*-value	Coefficient	SE	95%CI	*p*-value
RMSE	12.66				13.99			
R-square	-9.28				0.98			

Table 16 Care pathways affecting the target and non-target SBP (Full model)

Care pathways affecting target systolic BP (<140 mmHg) and non-target systolic BP (≥140 mmHg) (full model) (Log likelihood = -2197.33, AIC = 4429.57, BIC = 4515.68, ROC=0.59 in COVID-19 period and Log likelihood = -2551.13, AIC = 5132.27, BIC = 5227.07, ROC = 0.57 in post-pandemic).

Parameters	Coefficient	SE	95%CI	*p*-value
July 2021 and December 2021 (The covid-19 pandemic period)				
Care pathways				
-Discharge home with follow-up at hospital pathways	-	-	-	-
-PAH	0.92	0.24	0.44 - 1.40	<0.001
-DC	-0.20	0.32	-0.83 - 0.43	0.530
Sex				
Male	-	-	-	-
Female	0.39	0.15	0.10 - 0.69	0.010
Age group				
Age < 60	-	-	-	-
Age ≥ 60	0.57	0.17	0.23 - 0.91	0.001
BMI group				
BMI < 25 kg/m^2	-	-	-	-
BMI ≥ 25 kg/m^2	0.57	0.17	0.27 - 0.88	<0.001
Polypharmacy				
No	-	-	-	-
Yes	0.15	0.15	0.14 - 0.44	0.304

Table 16 Care pathways affecting the target and non-target SBP (Full model) (Cont.)

Parameters	Coefficient	SE	95%CI	*p*-value
July 2021 and December 2021 (The covid-19 pandemic period)				
Comorbidities				
≤2 diseases	-	-	-	-
> 2 diseases	0.34	0.17	0.01 - 0.66	0.042
Schemes				
UC	-	-	-	-
SSS	-0.27	0.19	-0.65 - 0.09	0.147
CSMBS	0.24	0.19	-0.14 - 0.62	0.210
Other	-0.14	0.34	-0.80 - 0.51	0.667
History of COVID-19 infection				
Yes	-	-	-	-
No	-0.26	0.26	-0.77 - 0.25	0.319
July 2022 and December 2022 (The post-pandemic period)				
Care pathways				
-Discharge home with follow-up at hospital pathways	-	-	-	-
-PAH	1.12	0.30	0.52 - 1.71	<0.001
-DC	-0.13	0.31	-0.75 - 0.49	0.680
Sex				
Male	-	-	-	-
Female	-0.07	0.13	-0.32 - 0.18	0.575

Table 16 Care pathways affecting the target and non-target SBP (Full model) (Cont.)

Parameters	Coefficient	SE	95%CI	*p*-value
July 2022 and December 2022 (The post-pandemic period)				
Age group				
Age < 60	-	-	-	-
Age ≥ 60	0.59	0.14	0.30 - 0.87	<0.001
BMI group				
BMI < 25 kg/m^2	-	-	-	-
BMI ≥ 25 kg/m^2	0.23	0.13	-0.02 - 0.48	0.081
Polypharmacy				
No	-	-	-	-
Yes	0.22	0.13	-0.03 - 0.47	0.081
Comorbidities				
≤2 diseases	-	-	-	-
> 2 diseases	-0.30	0.14	-0.57 - -0.03	0.030
Schemes				
UC	-	-	-	-
SSS	0.14	0.17	-0.19 - 0.47	0.397
CSMBS	0.21	0.16	-0.11 - 0.53	0.195
Other	0.21	0.32	-0.42 - 0.84	0.513
History of COVID-19 infection				
Yes	-	-	-	-
No	-0.08	0.17	-0.42 - 0.25	0.619

Table 17 Care pathways affecting the target and non-target DBP (Full model)

Care pathways affecting target diastolic BP (<80 mmHg) and non-target diastolic BP (≥80 mmHg) (full model) (Log likelihood = -2203.75, AIC = 4437.50, BIC = 4529.76, ROC=0.62 in COVID-19 pandemic and Log likelihood = -2574.42 , AIC = 5178.84, BIC = 5273.647, ROC = 0.65 in post-pandemic).

Parameters	Coefficient	SE	95%CI	*p*-value
July 2021 and December 2021 (The covid-19 pandemic period)				
Care pathways				
-Discharge home with follow-up at hospital pathways	-	-	-	-
-PAH	0.61	0.26	0.09 - 1.12	0.020
-DC	0.43	0.33	-0.21 - 1.07	0.190
Sex				
Male	-	-	-	-
Female	0.21	0.16	-0.11 - 0.52	0.207
Age group				
Age < 60	-	-	-	-
Age ≥ 60	-1.28	0.20	-1.68 - -0.88	<0.001
BMI group				
BMI < 25 kg/m^2	-	-	-	-
BMI ≥ 25 kg/m^2	0.98	0.18	0.63 - 1.33	<0.001
Polypharmacy				
No	-	-	-	-
Yes	-0.36	0.16	-0.68 - -0.49	0.023

Table 17 Care pathways affecting the target and non-target DBP (Full model) (Cont.)

Parameters	Coefficient	SE	95%CI	*p*-value
July 2021 and December 2021 (The covid-19 pandemic period)				
Comorbidities				
≤2 diseases	-	-	-	-
> 2 diseases	0.14	0.18	-0.20 - 0.49	0.419
Schemes				
UC	-	-	-	-
SSS	0.06	0.20	-0.34 - 0.45	0.779
CSMBS	-0.18	0.21	-0.60 - 0.23	0.386
Other	-0.98	0.39	-1.74 - -0.22	0.011
History of COVID-19 infection				
Yes	-	-	-	-
No	-0.08	0.28	-0.62 - 0.47	0.785
July 2022 and December 2022 (The post-pandemic period)				
Care pathways				
-Discharge home with follow-up at hospital pathways	-	-	-	-
-PAH	0.56	0.31	-0.04 - 1.16	0.067
-DC	0.24	0.28	-0.31 - 0.80	0.384
Sex				
Male	-	-	-	-
Female	-0.27	0.13	-0.53 - -0.02	0.032

Table 17 Care pathways affecting the target and non-target DBP (Full model) (Cont.)

Parameters	Coefficient	SE	95%CI	*p*-value
July 2022 and December 2022 (The post-pandemic period)				
Age group				
Age < 60	-	-	-	-
Age ≥ 60	-1.54	0.16	-1.85 - -1.22	<0.001
BMI group				
BMI < 25 kg/m^2	-	-	-	-
BMI ≥ 25 kg/m^2	0.76	0.14	0.49 - 1.02	<0.001
Polypharmacy				
No	-	-	-	-
Yes	-0.35	0.13	-0.60 - -0.10	0.005
Comorbidities				
≤2 diseases	-	-	-	-
> 2 diseases	-0.18	0.14	-0.45 - 0.09	0.185
Schemes				
UC	-	-	-	-
SSS	-0.33	0.17	-0.65 - -0.002	0.048
CSMBS	-0.39	0.17	-0.72 - -0.07	0.017
Other	0.21	0.32	-0.41 - 0.84	0.507
History of COVID-19 infection				
Yes	-	-	-	-
No	-0.13	0.17	-0.47 - 0.20	0.436

Table 18 Care pathways affecting the target and non-target FBS

Care pathways affecting target FBS (<130 mg/dL) and non-target FBS (≥130 mg/dL) (Log likelihood = -1073.60, AIC = 2173.21, BIC = 2244.33, ROC=0.64 in COVID-19 pandemic and Log likelihood = -1154.50, AIC = 2338.99, BIC = 2422.76, ROC = 0.58 in post-pandemic)

Parameters	Coefficient	SE	95%CI	*p*-value
July 2021 and December 2021 (The covid-19 pandemic period), stepwise model				
Care pathways				
-Discharge home with follow-up at hospital pathways	-	-	-	-
-PAH	-1.75	0.40	-2.53 - -0.97	<0.001
-DC	-2.01	0.48	-2.94 - -1.07	<0.001
Age group				
Age < 60	-	-	-	-
Age ≥ 60	-0.51	0.29	-1.08 - -0.06	0.077
Polypharmacy				
No	-	-	-	-
Yes	0.64	0.26	0.13 - 1.15	0.015
Comorbidities				
≤2 diseases	-	-	-	-
> 2 diseases	-0.910	0.32	-1.53 - -0.28	0.005
Schemes				
UC	-	-	-	-
SSS	1.08	0.36	0.37 - 1.79	0.003
CSMBS	0.34	0.33	-0.31 - 0.99	0.304
Other	0.13	0.61	-1.07 - 1.33	0.837

Table 18 Care pathways affecting the target and non-target FBS (Cont.)

Parameters	Coefficient	SE	95%CI	*p*-value
July 2021 and December 2021 (The covid-19 pandemic period), stepwise model				
History of COVID-19 infection				
Yes	-	-	-	-
No	0.50	0.53	-0.54 - 1.55	0.345
July 2022 and December 2022 (The post-pandemic period), full model				
Care pathways				
-Discharge home with follow-up at hospital pathways	-	-	-	-
-PAH	0.45	0.37	-0.28 - 1.19	0.225
-DC	-0.04	0.33	-0.69 - 0.59	0.891
Sex				
Male	-	-	-	
Female	-0.14	0.19	-0.52 - 0.23	0.461
Age group				
Age < 60	-	-	-	-
Age ≥ 60	0.21	0.20	-0.19 - 0.61	0.304
BMI group				
BMI < 25 kg/m^2	-	-	-	-
BMI ≥ 25 kg/m^2	0.54	0.19	0.15 - 0.92	0.006
Polypharmacy				
No	-	-	-	-
Yes	-0.13	0.18	-0.49 - 0.23	0.465

Table 18 Care pathways affecting the target and non-target FBS (Cont.)

Parameters	Coefficient	SE	95%CI	*p*-value
July 2022 and December 2022 (The post-pandemic period), full model				
Comorbidities				
≤2 diseases	-	-	-	-
> 2 diseases	-0.56	0.32	-1.55 - -0.28	0.005
Schemes				
UC	-	-	-	-
SSS	-0.16	0.25	-0.66 - 0.34	0.528
CSMBS	0.22	0.23	-0.24 - 0.67	0.349
Other	0.25	0.45	-0.65 - 1.34	0.588
History of COVID-19 infection				
Yes	-	-	-	-
No	0.51	0.25	0.01 - 0.99	0.045

Table 19 Number of patients in target and non-target surrogate marker in PAH pathway

Parameters	The duration of service (Month), N					
	1	**2**	**3**	**4**	**5**	**6**
PAH in COVID-19 pandemic						
SBP <140 mmHg	1	1	8	40	76	3
SBP ≥140 mmHg	2	1	9	36	88	5
DBP <80 mmHg	0	2	5	32	79	3
DBP ≥80 mmHg	3	0	12	44	85	5
FBS<130 mg/dL	2	1	7	32	118	5
FBS ≥130 mmHg	1	1	8	26	31	0
PAH in post-pandemic						
SBP <140 mmHg	-	2	4	11	42	5
SBP ≥140 mmHg	-	**5**	3	15	54	2
DBP <80 mmHg	-	3	4	14	53	4
DBP ≥80 mmHg	-	4	3	12	43	3
FBS<130 mg/dL	-	1	1	4	22	2
FBS ≥130 mmHg	-	6	3	19	62	3

Table 20 Number of patients in target and non-target surrogate marker in DC pathway

Parameters	The duration of service (Month), N					
	1	**2**	**3**	**4**	**5**	**6**
DC in COVID-19 pandemic						
SBP <140 mmHg	115	18	9	26	4	-
SBP ≥140 mmHg	76	11	17	16	3	-
DBP <80 mmHg	88	15	11	21	4	-
DBP ≥80 mmHg	103	14	15	21	3	-
FBS<130 mg/dL	125	13	13	29	5	-
FBS ≥130 mmHg	45	9	11	8	1	-
DC in post-pandemic						
SBP <140 mmHg	117	13	10	11	6	-
SBP ≥140 mmHg	77	7	4	2	0	-
DBP <80 mmHg	105	7	6	9	4	-
DBP ≥80 mmHg	89	13	8	4	2	-
FBS<130 mg/dL	50	8	3	6	3	-
FBS ≥130 mmHg	122	10	9	4	3	-

Table 21 The service duration affecting target and non-target surrogate markers in PAH and DC pathway

Parameters	Coefficient	SE	95%CI	*p*-value
Target SBP (<140 mmHg) and non-target SBP (≥140 mmHg) in PAH				
COVID-19 pandemic				
Durations ≤ 4 months	-	-	-	-
Durations > 4 months	0.20	0.25	-0.29 - 0.70	0.423
Post-pandemic				
Durations ≤ 4 months	-	-	-	-
Durations > 4 months	-0.13	0.38	-0.86 - 0.61	0.738
Target DBP (<80 mmHg) and non-target DBP (≥80 mmHg) in PAH				
COVID-19 pandemic				
Durations ≤ 4 months	-	-	-	-
Durations > 4 months	-0.32	0.26	-0.82 - 0.18	0.212
Post-pandemic				
Durations ≤ 4 months	-	-	-	-
Durations > 4 months	-0.11	0.37	-0.85 - 0.62	0.762
Target FBS (<130 mg/dL) and non-target FBS (≥130 mg/dL) in PAH				
COVID-19 pandemic				
Durations ≤ 4 months	-	-	-	-
Durations > 4 months	-1.22	0.30	-1.82 - 0.63	<0.001
Post-pandemic				
Durations ≤ 4 months	-	-	-	-
Durations > 4 months	-0.54	0.51	-1.54 - 0.45	0.286

Table 21 The service duration affecting target and non-target surrogate markers in PAH and DC pathway (Cont.)

Parameters	Coefficient	SE	95%CI	*p*-value
Target SBP (<140 mmHg) and non-target SBP (≥140 mmHg) in DC				
COVID-19 pandemic				
Durations ≤ 1 months	-	-	-	-
Durations > 1 months	0.22	0.25	-0.26 - 0.70	0.370
Post-pandemic				
Durations ≤ 1 months	-	-	-	-
Durations > 1 months	-0.71	0.35	-1.39 - -0.02	0.042
Target DBP (<80 mmHg) and non-target DBP (≥80 mmHg) in DC				
COVID-19 pandemic				
Durations ≤ 1 months	-	-	-	-
Durations > 1 months	-0.12	0.24	-0.60 - 0.36	0.627
Post-pandemic				
Durations ≤ 1 months	-	-	-	-
Durations > 1 months	0.20	0.31	-0.41 - 0.81	0.514
Target FBS (<130 mg/dL) and non-target FBS (≥130 mg/dL) in DC				
COVID-19 pandemic				
Durations ≤ 1 months	-	-	-	-
Durations > 1 months	0.29	0.29	-0.26 - 0.85	0.303
Post-pandemic				
Durations ≤ 1 months	-	-	-	-
Durations > 1 months	-0.63	0.34	-1.30 - 0.04	0.063

BIOGRAPHY

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Publications

1. Chongpornchai J, Tanyasansuk K and Sratthaphut L. Infographic and its applications in health and pharmacy. Thai bulletin of pharmaceutical science. 2016; 11(2):98-120.
2. Chongpornchai J, Tanyasansuk K and Sratthaphut L. Development of Infographic Media to Counsel HIV-infected Patients Receiving Antiretrovirals. Thai journal of pharmacy practice 2017;9(1):145-55.
3. Chinwong D, Mookmanee N, Chongpornchai J and Chinwong S. A comparison of gender differences in smoking behaviors, intention to quit, and nicotine dependence among Thai university student. Journal of addiction 2018:1-8.
4. Chongpornchai J, Phornprapa N and Sratthaphut L. Effectiveness of Motion Infographic Media on the Improvement of Knowledge and Medical Adherence in Human Immunodeficiency Virus Patients. Indian journal of pharmaceutical science 2021;83(3):562-68.