Public hospital organisation in Australia: A game theoretic & mechanism design-based approach

Sunil K. Dixit

B. Com, Agra University, Agra, India

Master of Business Administration (MBA), California State University, Fullerton, USA

Chartered Accountant (ACA), India

Certified Public Accountant (CPA), USA

Cost and Management Accountant (ACMA), India

Certified Management Accountant (CMA), USA

Dip MA, the Chartered Institute of Management Accountants, UK

Former Fellow, Royal Society for the encouragement of Arts, Manufactures and Commerce, UK

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ABSTRACT

Background: Public hospitals are expected to provide high quality services and also reduce or maintain the costs. Therefore, every aspect of healthcare service delivery has to be thoroughly examined. One of the ways to conduct a research inquiry into the organisation of healthcare service delivery is to analyse the interactions between healthcare providers. Game theory and the theory of mechanism design have been used to analyse the interactions between different parties that may have a principal-agent relationship. The delivery of healthcare services by public hospitals has policy implications because their activities are controlled by politicians and bureaucrats.

Purpose: This study seeks to investigate the strategic interaction-driven organisation or organising of healthcare services delivery by public hospitals by integrating: (a) institutional design, system thinking, and a structure-based approach; and (b) game theory, the theory of mechanism design and the principal-agent paradigm (delegation, policy implementation and bureaucratic capacity).

Methodology: This study uses average length of stay (ALOS) data for game theoretic policy implementation modelling. MATLAB was used to operationalise two game theoretic models: (1) a simplified social or prisoner's dilemma game; and (2) a prisoner's dilemma game with evolving cooperation in a social network.

Findings: The results of the two models presented in this study indicate that the more that hospitals play (interact or engage with each other), the more the defection rate decreases. Also, competition increases due to their interactions because the players' performance is relative to the maximum points scored at

the conclusion of a set of rounds. Therefore, early cooperation increases a player's scores and also the overall performance, yielding a higher benefit. In a public hospital system, hospitals do not need to compete with each other because all patients are covered by public insurance cover. However, it is in their best interest (and the interests of the general public) that they engage with each other and reduce the policy implementation error (PiE). These results also indicate that the higher the size of a group (N) is, the lower the cooperation rate would be.

Theoretical Implications: This research study brings together theories (game theory and the theory of mechanism design) and the three approaches to organisation or organising using game theoretical modelling. This study implicitly advances the goal of innovation in techniques and applications of empirical game theory (with the use of hospital data for simulation) by extending it to the healthcare research domain from computer sciences. It also extends the models of delegation, policy implementation error and bureaucratic capacity to healthcare research.

Practical implications: The models used in this research study simulate the results based on average length of stay (ALOS) in a hospital. A reduction in not only reduces spending, it also frees up beds for patients on the waiting list. It could become a foundation of a new regulatory framework.

Originality: There have been demands for theory integration both in organisational and healthcare research domains. This study integrates three approaches to organisation, game theory, the theory of mechanism design and the principal-agent paradigm to operationalise two game theoretic models of policy implementation. To the best of the researcher's knowledge, it is the first game theoretic study on the organisation of healthcare service delivery by public hospitals.

DECLARATION OF AUTHENTICITY

I, Sunil K Dixit, declare that the DBA thesis entitled *Public hospital organisation in Australia: A game theoretic & mechanism design-based approach* is no more than 65,000 words including quotes and exclusive of tables, figures, appendices, bibliography, references and footnotes. This thesis contains no material that has been submitted previously, in whole or in part, for the award of any other academic degree or diploma. Except where otherwise indicated, this thesis is my own work".

I have conducted my research in alignment with the Australian Code for the Responsible Conduct of Research and Victoria University's Higher Degree by Research Policy and Procedures.

Sunil K. Dixit

[redacted]

April 4, 2022

DEDICATION

कर्पूरगौरं करुणावतारं, संसारसारं भुजगेन्द्रहारम् ।
सदावसन्तं हृदयारविन्दे, भवं भवानीसहितं नमामि ।।

I dedicate this dissertation to *Lord Shiva and Maa Shakti* and my friend, guide, and the protector *Lord Krishna*. All my hard work and success is due to Him. I have nothing of my own as my place is at *Lord Krishna's* feet.

I could not have come this far without *Lord Krishna's* blessings. He gave me wonderful parents, the late Mr Vijaya Krishna Dixit, and Mrs Brij Rani Dixit. I hope my late parents are proud of my journey as a person and as their son while watching me from the Heaven.

When I was stuck midway through my research and did not know how to proceed to complete my dissertation, Professor Murali Sambasivan mentioned to me the eternal power of Jagadguru Shri Chandrasekharendra Saraswati Swamigal (also known as the Sage of Kanchi or Mahaperiyava). My prayers to Mahaperiyava showed me the way to implement the conceptual foundations of this research study into a game theoretic model.

I am immensely grateful and indebted to my wife Shivi and my daughter Sonum for having faith in my abilities. They both have been great moral support for me through thick and thin. They have sacrificed a lot while I worked on this research study.

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ABBREVIATIONS

ABF	Activity-based Funding
AIHW	Australian Institute of Health & Welfare
ALOS	Average Length of Stay
BC	Bureaucratic Capacity
AMI	Acute Myocardial Infarction (AMI)
DHS	Department of Health and Human Services
CFFR	Council of Federal Financial Relations
DRG	Diagnosis-related Group
ERASp	Enhanced Recovery after Surgery pathway
FOI	Freedom of Information
GP	General Practitioner
LHN	Local Hospital Network
MATLAB	Matrix Laboratory - Multi-paradigm Numerical Computing Environment and Proprietary Programming Language Developed by MathWorks
NHFB	National Health Funding Body
NHRA	National Health Reform Agreement
NoP	Number of Patients
OECD	Organisation for Economic Co-operation and Development
PdC	Per Day Cost of Stay at Hospital
PdR	Per Day Revenue for Stay at Hospital
PiE	Policy Implementation Error
PiEf	Policy Implementation Efficiency
PiS	Policy Implementation Status
PiS$	Dollar Value of the Policy Implementation Status
WHO	World Health Organisation

CHAPTER 1: INTRODUCTION

Healthcare is a key arena of the modernization of welfare states. Tighter resources and a changing spectrum of diseases, coupled with new modes of citizenship and demands for public safety, challenge the health care systems throughout the Western world…. … New forms of provider organisation, new actors – like the service users and the various health professions – and new regulatory patterns generate numerous shifts in the health care systems (Kuhlmann 2006, pp. 1, 5 & 6).

Healthcare service delivery is expected to be patient-friendly and driven by quality that provides value for money - what the patients need and when they need it (WHO 2008). Porter and Lee (2013) suggested that the healthcare system has to adapt to changes in the market as hospitals are expected to deliver a high quality of healthcare for a significantly lower cost. This is why the organisation of healthcare service delivery requires considerable thought and reflection on the role of government and society as governments try to get the best value for taxpayers' money.

Hospitals in Australia need to either increase their bed capacity or reduce the patients' length of stay or both because with regards to adults' access to healthcare, 10% of Australians had to wait for 4 months or more for elective surgery whereas only 4% of patients had to wait for elective surgery in France. There are concerns about the quality and adequacy of care that is being provided by the hospitals because 21% of patients had experienced a care coordination problem in the past two years. Similarly, 41% of patients reported gaps in hospital discharge planning in the past two years. Only 7% of patients experienced a care coordination problem in France. The public's view of the health system is also an area of concern as 48% percent of the public viewed the public health system as adequate, requiring only minor changes, and 43% saw a need for fundamental changes (Mossialos, Wenzel, Osborn & Sarnak 2016a).

The focus of this study is the strategic interaction-driven organisation[1] of healthcare service delivery by public hospitals in the Australian state of Victoria. In Australia, public hospitals are funded and controlled by the commonwealth, state, and territory governments. Politicians and bureaucrats play an important role in the organisation or organising of healthcare service delivery. This study specifically investigates the question: How is the strategic interaction-driven organisation of healthcare service delivery shaped by: (a) institutional design, system thinking and a structure-based approach; and (b) game theory, the theory of mechanism design and the principal-agent paradigm (delegation, policy implementation and bureaucratic capacity)?

1.1 Background of the study

Health is a matter of interest to individuals, society, businesses, and

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[1] As per Merriam-Webster (2003, p. 874), the term "organization [organisation]" includes, "the act or process of organizing [organising] or of being organized [organised]" or " the condition or manner of being organized [organised]." As per Cambridge University Press (2020) it includes " the way in which something is done or arranged" or " the way in which something is arranged." Therefore, the term "organisation" refers to the way in which healthcare services are delivered.

policymakers. The organisation of healthcare service delivery by public hospitals is influenced both by government and society. Although healthcare takes up a significant public policy space, no government has infinite resources to meet citizens' expectations; hence, difficult decisions need to be made (Boslaugh 2013). In addition, healthcare inherently is a collection of knowledge drawn from economics, sociology, organisation theories, political science, public health and different clinical areas (Mick & Shay 2014a).

It is no surprise that the study of organisation or organising is intriguing, particularly because there is virtually no part of modern life that has not been touched by organisations, therefore, imagining an economic or social activity without organisations would be impractical. Interestingly, the practice context appears to be missing in management and organisation studies (McLaren & Durepos 2019; Suddaby, Hardy & Huy 2011). This hinders not only the development of organisation theory but also has a negative impact on its application in the real world. Research based on scientific rationality that is divorced from a practical and social context omits the situational uniqueness which is an important element of practice (Sandberg & Tsoukas 2011).

There are several issues that influence the delivery of healthcare services. First, healthcare delivery by hospitals is facilitated or shaped by regulations, public policy, and society's expectations. Second, the relationships between hospitals and others are either implicit or explicit contracts. Third, hospitals use multidisciplinary teams of healthcare professionals to improve the patient experience, efficiency, and outcomes. Fourth, hospitals provide healthcare services to patients while no two patients are exactly the same. Last, in the case of public hospitals, politicians and bureaucrats play a significant role in the planning and delivery of healthcare services.

1.2 The gap in the existing knowledge

The task of organising has two elements: (a) the process of putting an organisation together by arranging the internal parties' relationships, information and rewards (incentives) to improve effectiveness; and (b) outcomes or results (Shortell & Kaluzny 1994). Healthcare assumes a great significance because it does not merely involve the treatment of diseases; nations today strive to adopt the concept of population health to attain healthy communities (Young 2004), thereby making the organisation of healthcare services complex. Even though healthcare organisations are multidisciplinary and complex, Mick and Shay (2014b) noted that a comprehensive or multitheoretical perspective of healthcare organisations is lacking. In organisational research, integration of two or more theories is missing. Clinicians' role in the success of healthcare organisations is already known. Therefore, a multidisciplinary organisation of healthcare delivery will only promote a coordinated role of the clinicians.

There have been several efforts to investigate and conceptualise a multitheoretical view of healthcare organisations (Dixit & Sambasivan 2019; Vogus & Singer 2016), however, such efforts do not take into account an integrated approach to the organisation or organising of healthcare services in general and by public hospitals in particular. Similarly, even though there have been a few research papers investigating the Australian healthcare system (Dixit & Sambasivan 2018; Glover 2015; Runciman, Hunt, Hannaford, Hibbert, Westbrook, Coiera, Day, Hindmarsh, McGlynn & Braithwaite 2012), the connection between organisational research and public hospitals' issues or problems is missing. The existing literature does not integrate two or more ways of organising in general and delivery of healthcare services in particular.

Both politicians and bureaucrats play an important role in the delivery of healthcare services by public hospitals. Huber and McCarty (2004) built a bureaucratic capacity model from the work conducted by Epstein and O'Halloran (1999). A bureaucrat may not have the personal capacity or resources to execute principals' orders or implement policies. In developed political systems, bureaucrats are expected to perfectly implement policies because they are viewed as experts in their fields (McCarty & Meirowitz 2007). However, a game theoretic organisation of healthcare services delivery driven by rules, system thinking and structure is not found in the existing literature.

Bureaucrats' inability to implement health policy can be problematic for a government that is accountable to the public because modern organisations represent a complex relationship mechanism under which different parties have different information and often encounter conflicting interests (Marschak 1989). The research in the field of delegation and bureaucracy has mostly focused on the United States. The lack of policy implementation research, generally in healthcare, and specifically in relation to public hospitals, is a glaring gap in the existing knowledge.

In addition to developing a multiperspective and multitheoretical understanding of organisation or organising, organisational research in the healthcare knowledge domain ought to bridge the gap between theorising and practice. There have been demands in the academic research community to advance theory integration because a single theory may not be adequate to answer all research questions (Dixit & Sambasivan 2019; Mayer & Sparrowe

2013). An organisational analysis of public hospital outcomes by integrating two or more theories or two or more approaches is lacking. Thus, the gaps in the literature can be summarised as follows:

a) Although healthcare services are delivered by teams of multidisciplinary professionals, an integrated perspective of the organisation of healthcare service delivery is absent.
b) Game theory, mechanism design theory and the principal-agent paradigm have been used to answer many research questions and solve problems in healthcare, yet their use for an organisational analysis collectively or separately is missing.
c) Research inquiries into the rules, system, and structure-based game theoretic organisation of healthcare service delivery by public hospitals are not found in the existing literature.
d) An integrated approach to research into public hospital outcomes by combining delegation of authority, bureaucratic capacity and policy implementation is lacking.

1.3 Research problem and issues

The organisation of healthcare service delivery could be characterised as a game in which different players seek to maximise their payoffs, hence, a social planner should be able to design a mechanism to achieve his/her goals. A social planner (also known as the principal) has the freedom of choosing and committing to any number of mechanisms, under classical mechanism design (Borgers, Krahmer & Strausz 2015; McCarty & Meirowitz 2007). Clearly, if seen in the context of the theory of mechanism design, modern healthcare service delivery can be defined as a representation of relationships between different parties based on contacts, incentives and information (Narahari 2014).

The main research problem, as highlighted in the preceding section, is the strategic interaction-driven multiperspective (three approaches) and multitheoretical (game theory, the theory of mechanism design, and the principal-agent paradigm - delegation, policy implementation and bureaucratic capacity) organisation of healthcare service delivery by public hospitals. Simply put, theory integration is missing in the existing knowledge in organisational research inside and outside Australia.

1.4 Objective of this study

There are three dimensions of the stated research problem: (a) an integrated view of the organisation of healthcare services by public hospitals; (b) policy implementation; and (c) a practical context (issues or problems facing public hospitals in the Australia). Thus, within this research framework, the four objectives of this study are to:

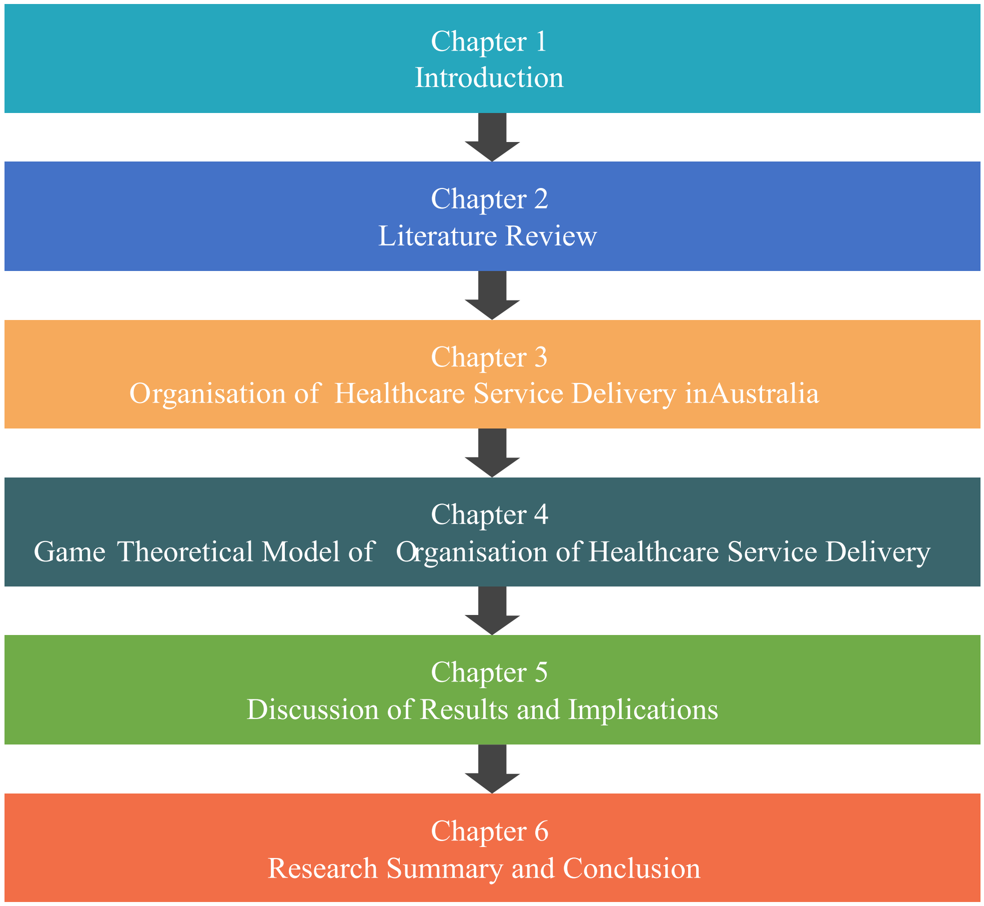
i. Explicate the approaches to the organisation of healthcare service delivery and the underpinnings of game theory, the theory of mechanism design and the principal-agent paradigm (delegation, policy implementation and bureaucratic capacity) for game theoretic modelling.
ii. Review the current state of the Australian healthcare system to identify the issues or problems to be used for game theoretic modelling.
iii. Design a game theoretic problem based on the policy implementation outcomes by integrating one or more problems encountered by public hospitals in Australia.
iv. Solve the game theoretic model by using the policy implementation

status (a combination of delegation, policy implementation and bureaucratic capacity).

1.5 Research Process

A literature review has been conducted to grasp the depth and breadth of the existing knowledge. The context of the study (delivery of healthcare services by public hospitals in Australia) has been fully explained by reviewing the Australian healthcare system. The review of the Australian healthcare system highlights several issues and problems. One of these issues (problems), (ALOS), has been used for game theoretic modelling. Sincere efforts were made to obtain the actual public hospital performance data. However, the state government did not provide the detailed data and information, as requested. Therefore, the researcher has used data that is available in the public domain with a modification for modelling, as needed. ALOS has been used to identify and analyse policy implementation and the bureaucratic capacity applicable to public hospitals in relation to the organisation of healthcare delivery. A review of the Australian healthcare system has been used to analyse the environment of the game, players, strategies, payoffs, and algorithms. The research process that was adopted to achieve the research objectives is shown in Figure 1.1.

Figure 1.1: Step-by-Step Research Process



1.6 Justification for the research

This research study is grounded in both theory and practice in relation to healthcare service delivery. It adopts a multi-perspective and multi-theoretical view of organisation of healthcare service delivery using policy implementation status. The rationale for undertaking this study to fill the gaps in the existing knowledge is as follows:

- This study's practical relevance stems from its niche carved out of organisational research that serves as the foundation of game theoretic modelling of (integrated) healthcare service delivery.
- This study's theoretical relevance can be found in the integration of game theory and the three approaches to the organisation (of activities).

It integrates the two research paradigms for the organisation of healthcare service delivery.

- This study's practical relevance can be also found in the game theoretical modelling that uses policy implementation status for the organisation of healthcare service delivery.

1.7 **Organisation of the study**

This thesis examines the literature on the four main topics in so far as they relate to: (a) approaches to organisation i.e., organising; (b) game theory (strategic interactions to achieve individual or organisational goals); (c) the theory of mechanism design (game theoretic strategic interactions to influence agent's behaviour); and (d) the principle-agent paradigm (game theoretic strategic interactions for policy implementation). It also reviews the Australian healthcare system. It then amalgamates the findings from the literature review and the review of the Australian healthcare system for game theoretic modelling for the organisation of healthcare service delivery. This thesis has been organised into 6 chapters as described below.

Chapter 1 introduces the background, gaps in the existing knowledge, research problems and issues, main objectives, research process and justification for the research.

Chapter 2 reviews the literature on the three approaches (institutional design, system and structure-based) for the organisation or organising of healthcare service delivery. These three approaches strengthen the (conceptual) pillars of the game theoretic modelling presented in this study.

Institution design refers to the creation of social rules and structures to facilitate the organising or organisation of activities (healthcare services).

Individuals, groups, and organisations that deliver healthcare services are all connected by social rules (e.g., code of professional practice, reimbursement mechanisms and an obligation to provide patient-centred healthcare services). The system approach to organisation helps with the identification of relationships between players and the influence of the environment on healthcare service delivery. The structure-based organisation of activities illuminates the key issues relevant to the design of the game theoretical model of this study.

Game theory not only provides the theoretical underpinnings of this study but is also used for modelling the policy implementation status for the purpose of the organisation of healthcare service delivery. Game theory is not only a theory, it is an art and science for decision-making (Dixit & Nalebuff 1993). While game theory, the theory of mechanism design and the principal-agent paradigm help with the identification of the players and the rules of the game, the approaches to organisation enrich the environment and validate the rules used for game theoretical modelling. While game theory is a paradigm for decision-making, the three approaches to organisation strengthen the theoretical foundations of this study.

In the same chapter, gaps in the existing knowledge are also highlighted. The rationale for this study is presented as well.

Chapter 3 discusses the organisation of public healthcare, public health insurance, public hospital funding, the role of public hospitals, key issues, and problems of public hospitals in Australia vis-à-vis similar healthcare systems in other countries, key players and different aspects of the public hospital service delivery in Australia. The work detailed in chapters 2 and 3 make possible the development of a game theoretical model which resembles the delivery of healthcare services in Australia (desired due to the policy implementation being the central theme of the organisation of healthcare service delivery by public hospitals). It magnifies what healthcare service delivery is and how it is delivered in Australia.

Chapter 4 presents the justification for using a multiperspective and multitheoretical research paradigm. It explicates the theoretical and conceptual foundations of this research study. It explains the purpose for choosing average ALOS for the game theoretic organisation of healthcare service delivery and describes the research methodology and data sources. It underlines policy implementation and bureaucratic capacity applicable to public hospitals in relation to the organisation of healthcare delivery. The game theoretic model developed in MATLAB, the environment of the game, rules, players, strategies, the payoff, the definition of the symbols used as well as the algorithms are also presented in this chapter.

Chapter 5 details the implementation of the models discussed in chapter 4 and presents a discussion of the results. It lists the policy implementation status data for different health conditions or procedures used for modelling. The ALOS for the following health conditions is selected for game theoretic modelling: (1) appendix removal; (2) caesarean delivery; (3) cellulitis; (4) chronic obstructive pulmonary disease with complications; (5) chronic obstructive pulmonary disease without complications; (6) gallbladder removal; (7) gynaecological reconstructive procedures: (8) heart failure with complications; (9) heart failure without complications; (10) hip replacement; (11) hysterectomy: (12) kidney and urinary tract infections with complications;

(13) kidney and urinary tract infections without complications; (14) knee replacement; (15) prostate removal and (16) vaginal delivery. A section of this chapter covers the visualisation of the data including a summary of the policy implementation status of public hospitals in Victoria. It also presents the results and implications of two models: (a) prisoner's dilemma game; and (b) prisoner's dilemma game with evolving cooperation.

Chapter 6 summarises the findings of this study. It also discusses the contribution of this study to existing knowledge, theoretical and practical implications, recommendations, limitations, and directions for future research.

CHAPTER 2: LITERATURE REVIEW

"Organizations dominate our socioeconomic landscape. Their influence in our everyday lives has increased steadily over time, particularly in the most developed regions of the world during the twentieth century. Today, we are born, work, pray and die in organizations, and, along the way, many of us derive our identities from our associations with them. …" (Baum 2002, p. 1)

2.1 Introduction

Since the main objective of this study is to conduct a research inquiry into the organisation or organising of healthcare service delivery by public hospitals driven by strategic interactions, in which game theoretic modelling focuses on policy implementation status, this chapter reviews the literature on the three approaches to organisation of healthcare service delivery, underpinnings of game theory, the theory of mechanism design, the principal-agent paradigm (an analysis of bureaucratic capacity to implement policy falls within the ambit of game theory – and mechanism design as it is a branch of game theory – in regard to the principle-agent paradigm) as well as their relevance to healthcare.

Section 2.2 presents a brief discussion on the concept of organisation and unpacks the three approaches to the organisation of healthcare service delivery.

Section 2.3 discusses game theory and its relevance to healthcare.

Section 2.4 critically evaluates the theory of mechanism design and its relevance to healthcare.

Section 2.5 describes the principal-agent paradigm (delegation, policy implementation and bureaucratic capacity) and its relevance to healthcare.

Section 2.6 presents the criticisms of game theory, the theory of mechanism design and the principal-agent paradigm.

Section 2.7 summarises the arguments in favour of using game theory, the theory of mechanism design and the principal-agent paradigm for the organisation of healthcare service delivery.

Section 2.8 summarises the literature review as follows: (a) purpose of organising; and (b) problems of organisation or organising.

Section 2.9 and 2.10 identify the gaps in the existing knowledge and present the rationale for undertaking this study.

Section 2.11 presents a summary of this chapter.

2.2 Organisation in healthcare

In addition to being a noun, organisation is also a verb underlying the importance of the processes by which internal structures are created including organisational interactions with external environment in the context of issues of power, interest groups and human beings' engagement (Van de Ven & Joyce 1981). Healthcare service delivery is based on multidisciplinary knowledge drawn from economics, sociology, organisation theories, political science, public health and different clinical areas (Mick & Shay 2014a). Modern healthcare organisations adopt evidence-based clinical and management practice to improve processes and performance (Zinn & Branson 2014). Although a collective or integrated multitheoretical perspective is lacking in modern healthcare organisations, a combination of different theories is used by various healthcare organisations (Mick & Shay 2014b).

There are three special considerations in regard to the organisation of healthcare service delivery. First, healthcare organisations can be defined as *institutions* since different individuals and groups pursue their agendas or perform their activities subject to some constraints, including socially constructed norms and the behaviour of agents guided by various codes and regulations; and those constraints are institutional (Goodin 1998). Second, coordinated efforts by multidisciplinary teams of professionals are required for effective and efficient healthcare services underlined by *systems and subsystems*. Last, healthcare organisations are *structured* differently due to the need to coordinate administrative and clinical activities (Baldwin, Dimunation & Alexander 2011) for the delivery of healthcare services that involve human lives. These three approaches to the organisation of healthcare service delivery are discussed next.

2.2.1 Institutional design-based approach to organisation

Instead of diving deep into the controversy regarding the definitions of organisations and institutions, this study takes a simple interpretation of the two terms. Organisations comprise individuals and groups that come together to achieve their collective goals while complying with a rule-based mechanism (Goodin 1998) that can be called institutional design. Institutional design in the context of public hospitals is complicated by the involvement of politicians, bureaucrats, and legislative bodies.

As per (Hodgson 2006): *"Institutions are systems of established and embedded social rules that structure social interactions."* Furthermore, both public and private hospitals can be defined as institutions because healthcare professionals and organisations are required to adhere to regulations, standards of healthcare delivery, accreditation, and professional codes of conduct. Political institutions, regulations, suppliers, healthcare professionals, managers, patients and society are all part of the institutional design of public hospitals, whose performance is measured by positive (success) and negative (failures) outcomes of an organisation (Warsh 2016).

Institutions are a set of rules with an enforcement mechanism to shape or structure interactions (for the delivery of healthcare services to patients) between individuals through incentives and constraints. Incentives and disincentives are respectively the outcomes of benefits or barriers that arise out of the application of a rule. An incentive mechanism is much broader than monetary remuneration as it includes formal contracts between parties, laws and informal norms (Meessen, Musango, Kashala & Lemlin 2006). Organisations create structures that cannot be operationalised without a system of rules, therefore, it can be argued that organisations are a part of institutions (Hodgson 2015).

While institutional design can be defined as a set of rules, norms of behaviour and contracts, organisational practice refers to their implementation framework. Institutional design is embedded in the delivery of healthcare services both by healthcare organisations and healthcare professionals. A third party (e.g., government, professional licensing authorities, accreditation institutions) may be required to enforce the rules. The role of institutional design in public policy formulation cannot be ignored. Shah (2021) argued that Covid-19 has put India's health system to test, hence, state capacity and institutional design framework needs to be re-evaluated. Ground rules, transparency and a clear definition of roles can be used for a collaborative process of stakeholder management by medical leaders (Jones, Armit, Haynes & Lees 2022).

The following barriers to institutional design exist: the lack of or inadequacy and contradictions of rules; weak rule enforcement; limited organisational capacity; and ineffective interorganisational relationships. Since the performance of an organisation depends on institutional design, organisations carry out their activities in an institutional context (Mathauer & Carrin 2011).

2.2.2 Systems approach to organisation

The need for a systems approach arose when heterogeneous knowledge had to be put together along with the man-technology relationship (von Bertalanffy 1968) to achieve a goal. Organisations are open yet complex systems comprising many subsystems that are interdependent and, hence, they must be studied as a whole (Ackoff 1981). Organisation, as a process of social cognition, could be a reflection of the relationship between a system and its environment with four elements: strategic choice, domains of interactions, identity formation and shared meanings configured by two design rules – procedural and practice-based (Magalhaes 2011). While it is reasonable to hold individuals accountable when adverse events occur in a hospital, a holistic view of the hospital as a system would be necessary to identify the weaknesses as a whole (Anderson 2016).

Mathematical modelling is difficult because healthcare service delivery can be defined as a complex (nonlinear) system that involves a rapidly changing environment and dynamic synchronous and asynchronous interactions between people, systems and subsystems (Berwick & Hackbarth 2012). A system thinking approach to value-based healthcare service delivery is desirable to unpack the complexities of coordination (Strachna & Asan 2021) among the members of multidisciplinary teams.

Physicians and other clinicians' roles in healthcare service delivery have been investigated by many researchers. A good hospital-physician relationship is based on transparent and open communication and the integration of physicians' decision-making in relation to patient care, accountability and quality (Spaulding, Gamm & Menser 2014). Clinicians play an important role in the delivery of quality healthcare services to patients (Veronesi, Kirkpatrick & Vallascas 2013). In order to strengthen physicians' engagement and leadership, capacities must be built at the individual, organisational and system level (Denis et al. 2013). Systems thinking applications could be instrumental in solving complex problems surrounding the delivery of high-quality health care (Khalil & Lakhani 2022). At a conceptual level, a hospital could be viewed as a four-layered system that consists of patients, care teams, organisation and environment (Reid, Compton, Grossman & Fanjiang 2005).

2.2.3 Structure-based approach to organisation

Organisational structure can be defined as the formal relationships, coordination and responsibility arrangements among the members of an organisation (Shukri & Ramli 2015) to facilitate decision making to achieve the aims of that organisation. Alternatively, this can be called the organisational management structure (Wagner, Mannion, Hammer, Groene, Arah, Dersarkissian & Suñol 2014). Although organisation design focuses mainly on formal structures, Carroll and Rudolph (2006) extended it to include policies, procedures and practices to operationalise organisational structures. Outcomes or performance is the result of the activities driven by organisational structure.

The emergence of the professionalisation and specialisation of healthcare professions has prompted changes in organisational structures. Patient-centred healthcare service delivery requires transformation of organisational structures to achieve efficiency (Martinez Ibañez, Ochoa de Echagüen, Campos & Romea 2021). Organisation structure and organisational positioning can be used in relation to healthcare organisations by focusing on: a consideration of the payer, physician, continuum of services and health system environment; sustainable health delivery models through the creation of networks based on organisational capabilities and; preparing and adapting to changing markets (Engler, Jones & Van de Ven 2013). The structure of a healthcare service delivery organisation ought to accommodate the needs of physicians and surgeons, as they are the main source of patient referrals and revenue generation. In order to provide high-quality care, healthcare organisations need evidence-based management and a proper error reporting mechanism. A carefully developed organisational structure is helpful in facilitating error reporting and other decision-making (Wawersik & Palaganas 2022).

A scoping review of the three approaches to the organisation of healthcare service delivery reveals some interesting insights. First, as a verb, organisation may be interpreted as the act of putting different things together. Second, the foundation of modern healthcare delivery is multidisciplinary. Third, institutional design refers to a set of rules or social norms, individuals, organisations, and interactions that are used for the delivery of healthcare services. Fourth, the systems approach underpins the importance of the study of healthcare organisations as systems and subsystems. Fifth, the structure-based approach complements institutional design as policy, practices, rules, and other arrangement of responsibilities drive the activities of an organisation.

Since it is an interaction-based game theoretic research study, the engagement among different players would obviously be shaped by the five findings of this review mentioned in the previous paragraph. Without considering the three approaches to the organisation of healthcare services, the social planner (in the context of the theory of mechanism design) would face difficulty in achieving his or her goals as the players are public hospitals (not individuals). A summary of the key elements of the three approaches to the organisation of healthcare service delivery is shown in Table 2.1.

Table 2.1: Summary of the main elements of approaches to organisation design

Criteria	Main contributors	Activities of organisations	Expected outcomes
Institutional design	Goodin (1998); Hodgson (2006); Hodgson (2015); Mathauer and Carrin (2011); Meessen et al. (2006); Shah (2021); and Warsh (2016)	Individuals and organisations come together to deliver healthcare as per the rules, social norms, and public policy. Incentives and disincentives are instituted for individuals and the organisations to seek their cooperation.	Outcomes for which rules and norms for interaction were applied (e.g., quality, effectiveness efficiency) for the delivery of healthcare to patients.
Systems approach	Ackoff (1981); Anderson (2016); Denis et al. (2013);Berwick and Hackbarth (2012); Magalhaes (2011); Reid et al. (2005); Spaulding, Gamm and Menser (2014); Strachna and Asan (2021); Veronesi, Kirkpatrick and Vallascas (2013); and von Bertalanffy (1968)	The optimisation of systems and subsystems comes under pressure from the external environment. Systems and subsystems are to be brought to a steady state. Systems encompass patients, care teams, organisations, and the environment.	Delivery of healthcare (quality, efficiency, and patient satisfaction) to patients by steady and optimised systems and subsystems.
Structure-based approach	Carroll and Rudolph (2006); Engler, Jones and Van de Ven (2013);Martinez Ibañez et al. (2021); Shukri and Ramli (2015); and Wagner et al. (2014)	Create and adjust a formal management structure to facilitate decision making. Create policies and procedures to operationalise structures and for competitive positioning.	Flow of information and formal relationships for operational improvement (e.g., reduction in waitlists). Patient-centred healthcare delivery by multidisciplinary teams of healthcare professionals.

2.3 Game theory

The history of game theory can be traced back to a 2,000-year-old collection of Jewish laws (*Talmud),* when the division of the estate of a dead man among his three wives could differ depending upon the value of the estate he left behind. Nearly two millennia later, it was recognised as a cooperative game by Aumann and Maschler (1985). Game theory has two branches, known as cooperative and noncooperative game theory. Cooperative game theory relies on rationality, unlimited communication, and an ability to make agreements. Noncooperative game theory assumes rationality, detailed information regarding the players' strategies and alternative outcomes (Brandenburger 2007). A noncooperative game equilibrium for the leader and follower was introduced by Von Stackelberg (1934). Professor John Forbes Nash, Jr. introduced the noncooperative equilibrium or the Nash equilibrium (Nash 1950, 1951) to show that players in a game can improve their payoffs by making unilateral moves.

Game theory is not merely a theory; it is an art as well as a science practiced for decision making by players who are rational and strategic (Dixit & Nalebuff 1993; Geckil & Anderson 2009). It underpins a logical and mathematical analysis to predict the outcome (or outcomes) of interactions between cooperative as well as noncooperative strategic players or decision makers who are both intelligent and rational (Narahari 2014). A game basically has three essential features. First, there should be at least two players. Second, the players interact (strategies) with each other, and each player receives a payoff as a result of playing the game. Third, if a player's utility or payoff is known only to himself, it will be a static game with incomplete information (Banerjee 2014;

de Vries & Yehoue 2013).

2.3.1 Strategies in game theory

A dominant strategy is one that gives a player the best payoff, irrespective of what the other players do. If each player has a dominant strategy, the combination of strategies and payoffs is called a dominant equilibrium (McCain 2010). A mixed strategy is a set of strategies with assigned probabilities belonging to each player, allowing him to randomly use any of them. A mixed strategy Nash equilibrium is a combination of strategies and payoffs where players' choices are driven by probabilistic rules (Osborne & Rubinstein 1994).

2.3.2 Game theory in healthcare

Game theory has been used to study a variety of problems in health care, such as, stockpiling critically necessary supplies to prepare for a flu pandemic (DeLaurentis, Adida & Lawley 2008); physicians' preferred items in the supply chain (Dienes 2011); modern healthcare as a game theory problem (Djulbegovic, Hozo & Ioannidis 2015); a game theoretic perspective of patients' trust and continuity of care (Tarrant, Dixon-Woods, Colman & Stokes 2010); its use in public healthcare (Westhoff, Cohen, Cooper, Corvin & McDermott 2012); the management of personal protective equipment during Covid-19 (Abedrabboh, Pilz, Al-Fagih, Al-Fagih, Nebel & Al-Fagih 2021); countries competing for the supply of medical items (Salarpour & Nagurney 2021) ; and a purchaser's willingness to pay for healthcare (Yaesoubi & Roberts 2010).

2.4 Theory of mechanism design

The origins of mechanism design theory can be linked to the work of Hurwicz (1960) who argued that: (a) central planning failed because of information asymmetry among the economic players; (b) there was a lack of incentives for the economic agents to truthfully reveal their private information; and (c) the market mechanism was also influenced, though to a lesser degree if compared to central planning, by incentive problems. Hurwicz (1972) also introduced the concept of 'incentive compatibility' and underlined the importance of sharing the private information possessed by all the participating economic agents under a mechanism. Even if such a mechanism cannot achieve an optimal outcome and each agent's incentives are compatible, Pareto efficiency could not occur due to information asymmetry. Thus, mechanism design theory seeks to obtain 'incentive efficiency' with compatible incentives (Myerson 1979) in such a way that no economic agent can do better without another agent doing worse.

Mechanism design theory also seeks to address one of the major problems in economics – getting a result from the strategic interactions of rational players so that the outcome suits all of the self-interested players (Cihák 2008). Mechanism design refers to the selection of a game (as in game theory) by a principal for his agents to achieve the desired outcomes or results (McCarty & Meirowitz 2007). A principal (who has limited information or knowledge or expertise) hires agents (who have better information or knowledge or expertise) to achieve a desired outcome (Samuelson & Marks 2008). When an agent takes actions, which are hidden from the principal, or hides information from the principal, the problems of a *moral hazard (or incentive problem)* and *adverse selection* arise (Campbell 2006; Stiglitz 2000). A principal may create incentives to mitigate the problems of adverse selection and moral hazard and induce his agents to work towards achieving the outcomes desired by the principal (McCarty & Meirowitz 2007).

2.4.1 Mechanism design theory in healthcare

Mechanism design has been used in healthcare to simulate a new insurance system under healthcare reforms in China (Liang, Yamaki & Sheng 2009); for the optimal financing structure of healthcare insurance (Zhu 2012); for scenarios when the valuation of an agent depends on what type the other agents are (Nath, Zoeter, Narahari & Dance 2015); for the optimal mechanism for managed care (Chone & Ma 2011); the adoption of generic pharmaceuticals (Iizuka 2012); incentives and compensation for healthcare providers (Allard, Cremer & Marchand 2001); healthcare blockchain system (Jung, Kim, Hwang & Hong 2021); multi-strategy health insurance plans in which patients' motivation to hide private information is eliminated (Sun, Wang & Steffensen 2022); and moral hazard in healthcare insurance (Aron-Dine, Einav, Finkelstein & Cullen 2015).

2.5 The principal-agent paradigm (delegation, policy implementation & bureaucratic capacity)

Delegation (of authority) by politicians to bureaucrats is necessary because political leaders cannot implement the policies by themselves (Shipan 2004). Politicians appoint or select bureaucrats as agents who possess expert knowledge and are better informed than the principals (Weingast & Moran 1983). In political science, rational choice theorists use the principal-agent relationship to study public policy outcomes (Ishiyama & Breuning 2010). Public or political institutions encounter the problem of information asymmetry when one side has the authority while the other has the information and expertise.

As per Huber and McCarty (2004), new policy initiatives emerge from the federal and state governments as their bureaucratic capacity increases. If the agencies are competent, their ability to implement new programs will increase, resulting in better payoffs for all the actors. If the agencies are incompetent, or lack the capacity to implement policies, the politicians will give the bureaucrats more flexibility so that they do not ignore the policies altogether. Therefore, a social planner would be interested in understanding how the delegation and policy formulation processes are shaped by the interaction between policy expertise and bureaucratic capacity.

The most fundamental argument to emerge from the models of bureaucratic delegation is that politicians will delegate more powers to bureaucrats as their policy uncertainty increases vis-à-vis the bureaucrats' policy uncertainty (Epstein & O'Halloran 1994, 1999; Huber & Shipan 2011). As a result of the rich body of knowledge in the field of delegation to bureaucrats, much attention has been paid to the principal-agent relationship and bureaucratic capacity. Bolton, Potter and Thrower (2014) suggested that studies should consider the institutional capacity, because it may hinder or foster the implementation of the policies and their outcomes.

Squire (1998) noted that the professionalism and efficiency of a legislature increases the volume of lawmaking. Perhaps the professionalism of the legislature prompted the Lieutenant Governor of Michigan to call for the deprofessionalisation of the state legislature to boost the efficiency of the state government (Boushey & McGrath 2014). Legislative professionalism was used by Squire (1992) in the context of an institution with the attributes of salary, staff and time in session. Squire (2007) again tested the reliability and validity of the professionalism index developed by him in 1992 and found that it was still relevant. In a principal-agent relationship, accountability flows from the government, through the elected representatives, to the citizens who elected them (Dowding & Lewis 2012).

Thatcher and Sweet (2002) used the term 'non-majoritarian institutions' in Europe to define institutions that are neither elected by the people nor directly managed by the elected representatives. Buthe (2010) contended that most of the principal-agent literature is fixated on the need for delegation and the selection of agents and mechanisms to monitor the agents. The author then examined the dynamic relationship between the principal and agent that evolves post-delegation. As both principal and agent enhance their specialisation, other parties will become interested and vested in the relationship. The agent will then promote his own base or relationships which in turn will make institutional changes less likely. In this case, the agent may move farther away from the policy point where the principal prefers to be, without facing the risk of being removed.

2.5.1 Delegation and bureaucratic capacity in healthcare

There is a special principal-agent relationship between physicians and patients, and between physicians and hospitals. Physicians are considered double-agents as they are required by the ethics of their profession to be loyal to the patients while they are also expected to keep healthcare costs down, as per the insurance companies' (in the case of public hospitals, the government's) reimbursement protocols (Shortell, Waters, Clarke & Budetti 1998). In a basic market model, buyers know what they are buying and the benefits they will receive from the products or services to be bought. However, in the healthcare market, patients have to seek the physicians' – who are healthcare providers or have been engaged by a principal to work as agents – recommended healthcare choices. A potential solution to the problem of this double agency could be the hiring of physicians as salaried employees (Baily 2004).

In countries where healthcare services are funded by taxpayers, the concept of bureaucratic capacity is quite relevant because the performance of government-funded organisations depends on the effectiveness of policy formulation and implementation. Bureaucratic capacity has been discussed with regards to policy reforms in Thailand (Kuhonta 2017); truncated bureaucratic capacity for Medicare design resulting in poor implementation of the programs (Morgan & Campbell 2011); bureaucratic capacity during Covid-19 (Annaka 2021; Pedersen & Gay 2021); and government program performance (Meier, Rutherford & Avellaneda 2017).

2.6 Criticism of game theory, mechanism design and the principal-agent paradigm

Game theory has been criticised for three of its elements or assumptions, namely, its rationality, indeterminacy and inconsistency (Kelly 2003). Game theory assumes that economic players are rational and seek to achieve equilibrium through their actions or strategies, however, the players may act irrationally and use non-equilibrium strategies if they believe other players will adopt a similar approach (Kim 2014). The following criticism of game theory was underlined by Grüne-Yanoff and Lehtinen (2010):

(a) A mixed strategy is a manifestation of the probabilistic distribution of a range of pure strategies chosen by a player. What if a player is indifferent towards equilibrium between a randomised strategy and any pure element of randomisation, when such randomisation is costly in terms of money and time?

(b) One-shot Nash equilibria has been criticised for its assumption that a player perceives his own deliberations as a simulation of the other players' deliberations.

(c) It cannot be established that players do play the Nash equilibrium.

(d) The application of a revealed preference makes game theory inconsistent, and it is conceptually infeasible to structure a game on the basis of revealed preferences.

The mechanism design theory is criticised on the grounds that the optimal solutions emerging from a social planner's well-articulated problem are too complex, as researchers tend to focus more on robustness than the environment in which the players function (Bergemann & Morris 2005). Others too have expressed the following concerns regarding the mechanism design theory:

(a) A negotiation between a buyer and seller takes place because a seller would always exaggerate the value of the goods he intends to sell, whereas the buyer would always look for a lower value. The Myerson–Satterthwaite theorem does not address this issue, which can delay the auction and even result in the failure of the negotiations (Milgrom 2004).

(b) The mechanism design theory neglects to pay enough attention to the issues of information exchange and the costs of information processing and the choice of equilibrium (Saijo 2007). Though mechanism design theorists assume that strategic players will participate in a game designed by a social planner, Saijo (2008) designed a two-stage game where the first stage was left to the participants' choice.

(c) Nwogugu (2012) contended that the mechanism design theory is flawed on account of the following reasons: (i) it does not account for the confidentiality of information that the agents may be withholding; (ii) it does not account for the various types of costs and sanctions; (iii) the agents' information processing abilities, the value of information to the agents, the agents' response to incentives, and the designed mechanisms' information processing are neglected by the mechanism design theory.

Kivistö (2007) presented a succinct account of the criticism of the principal-agent paradigm (agency theory). First, it has been criticised because of the behavioural assumptions it makes about agents by neglecting the positive aspects of the agents' behaviour. Second, it has empirical shortcomings as it makes no predictions on the basis of the variables. Third, it cannot be used as a conceptual framework because of its narrow focus and disregard for other parties, such as the stakeholders. Last, it has been criticised for its application to public and non-profit organisations. Shapiro (2005) argued that the principal-agent paradigm (agency theory) conveniently uses opportunistic agents for computations while ignoring other significant issues. While calling it an organisational theory without organisation, Kiser (1999) suggested that economists should integrate social aspects, different principals and third parties in their models.

2.7 The appeal of game theory and the theory of mechanism design

Game theory and the theory of mechanism design appeal to both researchers and practitioners as these theories have been used in economics, business, healthcare, computer sciences, village economies and climate agreements (Garg, Narahari & Gujar 2008; Martimort & Sand-Zantman 2011; Townsend & Mueller 1998). Game theory and the theory of mechanism design have both been used empirically to simulate payoffs and to find optimal solutions to a variety of problems (Jordan, Schvartzman & Wellman 2010; Vorobeychik, Kiekintveld & Wellman 2006; Wellman 2016). The theory of mechanism design adds an interesting branch to game theory as a designer or a social planner seeks to maximise the utility by making an optimal choice of the rules of a game based on the assumption that the players will act rationally (Borgers, Krahmer & Strausz 2015; McCarty & Meirowitz 2007). Furthermore, Page (2012) examined the complexity of the aggregate behaviour of strategic players for institutional mechanisms design and advocated the consideration of outcome phenomena instead of equilibria. Game theory, the theory of mechanism design and the principal-agent paradigm are closely connected/interdependent theories and concepts as shown in Table 2.2.

Table 2.2: A summary of the theories and concepts under the game theory umbrella

Theory	Main characteristics
Game theory	Different rational players (individuals, groups or organisations) interact with each other for a payoff, outcome or utility (Dixit & Nalebuff 1993; Narahari 2014)
Theory of mechanism design	A social planner (principal) seeks to shape the interactions among different rational players (individuals, groups or organisations) to achieve the goals desired by him. In other words, the theory of mechanism design is the reverse game theory, as it sets optimal rules for the games (Borgers, Krahmer & Strausz 2015, p. Abstract).

Principal-agent paradigm (delegation), policy implementation and bureaucratic capacity	It is the relationship between the principal and the agents (Shortell et al. 1998). It is also the principal-agent relationship in the context of health policy, as the politicians have to delegate policy making and implementation to the bureaucrats (Huber & McCarty 2004, 2006).

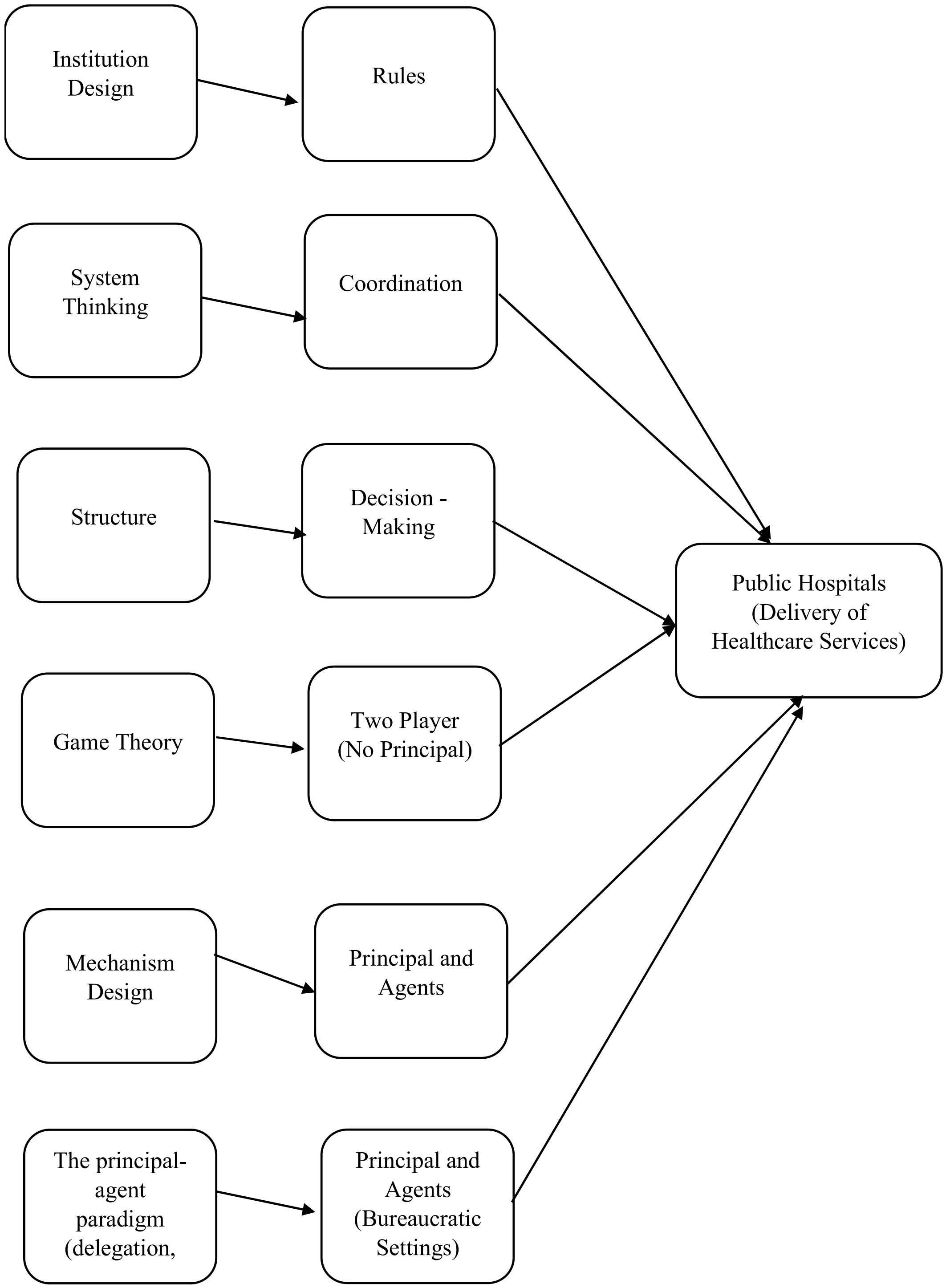
A summary of the underpinnings of game theory, mechanism design and the principal-agent paradigm (delegation, policy implementation and bureaucratic capacity), including their relevance to this study, is shown in Table 2.3. Figure 2.1 shows the relationship between the approaches and theories reviewed in this study.

Table 2.3: A summary of game theory, the theory of mechanism design & the principal-agent paradigm

Criteria	Game Theory and Mechanism Design Theory	Principal- Agent Paradigm (Delegation, Policy Implementation and Bureaucratic Capacity)
Main Contributors	Abedrabboh et al. (2021); Allard, Cremer and Marchand (2001); Aron-Dine et al. (2015); Aumann and Maschler (1985); Banerjee (2014); Chone and Ma (2011); Cihák (2008); Brandenburger (2007); Campbell (2006); de Vries and Yehoue (2013); DeLaurentis, Adida and Lawley (2008); Dienes (2011); Dixit and Nalebuff (1993); Djulbegovic, Hozo and Ioannidis (2015); Geckil and Anderson (2009); Hurwicz (1960); Hurwicz (1972); Iizuka (2012); Jung et al. (2021); Liang, Yamaki and Sheng (2009); McCain (2010); McCarty and Meirowitz (2007); Myerson (1979); Narahari (2014); Nash (1950); (Nash 1951); Nath et al. (2015); Osborne and Rubinstein (1994); Salarpour and Nagurney (2021) Samuelson and Marks (2008); Stiglitz (2000); Sun, Wang and Steffensen (2022); Tarrant et al. (2010); Von Stackelberg (1934); Westhoff et al. (2012); Yaesoubi and Roberts (2010); Zhu (2012);	Annaka (2021); Baily (2004); Bolton, Potter and Thrower (2014); Boushey and McGrath (2014); Buthe (2010); Dowding and Lewis (2012); Epstein and O'Halloran (1994); Epstein and O'Halloran (1999); Huber and McCarty (2004); Huber and Shipan (2011); Ishiyama and Breuning (2010); Kuhonta (2017); Meier, Rutherford and Avellaneda (2017); Morgan and Campbell (2011); Pedersen and Gay (2021); Shipan (2004); Shortell et al. (1998); Squire (1992,1998 and 2007); Thatcher and Sweet (2002) and Weingast and Moran (1983)
Objectives	Game theory: highlight the conflict or cooperation among strategic and rational players. Mechanism design: design of a Bayesian game to align a social planner's objectives with the objectives of his agents.	Align the interests of a principal with the objectives of his agents by addressing the agency problem.

Key Themes	Strategic interaction; cooperative games; noncooperative games; equilibrium; dominant, pure and mixed strategies; utility; payoffs; social planner; Nash equilibrium.	Moral hazard; adverse selection; agency problem; delegation; bureaucratic capacity; and policy implementation.
Expected Outcomes	Game theory: analyse conflict and cooperation under different scenarios in an efficient organisation. Mechanism design: align the interests of a social planner or principal or an organisation with the interests of agents.	Reduce the agency costs and policy implementation.
Criticism	Game theory: players may act irrationally; and a player may be indifferent towards equilibrium. Mechanism design: too complex; not enough attention to information exchange; players' choice to participate in a mechanism designed by a social designer has not been given attention; the issue of the confidentiality of information has been neglected; and agents' information processing abilities are not considered.	Flawed behavioural assumptions; no predictions based on variables; narrow focus; and social aspects are neglected.
Relevance to Healthcare	Health policy and hospital outcomes games; mechanism design for optimisation of hospital outcomes.	Bureaucratic capacity and health policy implementation.
Elements of Organisation	Players, agents, strategies, payoffs, contracts, delegation and social planner/principal	Health policy implementation, bureaucratic capacity, incentives, agency costs, moral hazard, adverse selection, physicians and other healthcare team members as agents and principal's desired goals.

Figure 2.1: Relationship between the approaches and theories reviewed in this study



2.8 Summary of literature review

A multiperspective (the three approaches to organising) and multitheoretical (game theory, the theory of mechanism design and the principal-agent paradigm) literature review illuminates the importance of institutions, systems, and structures for organising the delivery of healthcare services. Game theory is an analysis of choices that different players (e.g., principals and agents) make while interacting with each other to achieve their objectives. Mechanism design theory and the principal-agent paradigm together are instrumental in designing a scheme or a plan or a mechanism or a system (of incentives, punishment, etc.) so that the agents will deliver what the principal expects them to. Game theory and the theory of mechanism design complement each other as the theory of mechanism design is merely an extension of game theory.

2.8.1 The three approaches to organisation address the criticisms of game theory, the theory of mechanism design and the principal-agent paradigm

Critics argue that players may be irrational. To reduce the possibility of irrational behaviour, institutional design can be used as a framework for identifying and evaluating players' strategies. Critics argue that players may be indifferent towards equilibrium. If the players are tied within an organisational structure, they would be interested in engagement with other players for their benefit and the benefit of their organisations. Critics argue that revealed preferences make game theory inconsistent. System thinking alleviates that fear to some extent because healthcare service delivery has too many interconnected components ranging from healthcare professionals' expertise to the availability of modern technology. Critics argue that parties may exaggerate the value of goods (services) and also that confidential information in the possession of players can be problematic. The public hospital system is open to all players. They are able to see the activities and performance of every hospital in the system. Therefore, these approaches provide an impetus for an analysis of players' engagement with each other devoid of the criticism of game theory, the theory of mechanism design and the principal-agent paradigm.

2.8.2 Purpose of organising

The theoretical frameworks reviewed in this chapter reveal the different aspects of organising and organisation (as verbs). The institutional design approach to organisation design underlines the significance of rules, social norms, incentives, and disincentives or punishments. A system approach to organisation portrays organisations as systems and subsystems that are to be optimised (since healthcare services are delivered by interdisciplinary teams of healthcare professionals). A structure approach to organisation design concentrates on the arrangement of responsibilities and relationships to facilitate decision making. While game theory can help analyse the payoffs for interacting players depending on their strategies, the mechanism design theory and principal-agent paradigm help a social planner design a mechanism (or devise an action plan) for effective policy implementation (e.g., delivery of healthcare services).

2.8.3 Problem of organisation or organising

It is clear from the literature reviewed in this chapter that: (a) none of the three approaches to organisation or organising *alone* may be the basis of a theoretical and practical foundation of healthcare service delivery; and, (b) while game theory, mechanism design theory, and the principal-agent paradigm may be effective for an analysis of interactions among different players, a holistic understanding of the organisation of healthcare service delivery is possible if the three approaches to organisation or organising are also taken into consideration.

2.9 Gaps in existing knowledge and motivation for this study

Healthcare service delivery require a multiperspective and multitheoretical understanding of organisations and organising. Although there is a demand for multitheoretical research, the existing literature is either silent or inadequate in this regard. The following gaps in the existing literature have been identified:

a) Although healthcare services are delivered by teams of multidisciplinary professionals, an integrated perspective of the organisation of healthcare service delivery is absent.

b) Game theory, mechanism design theory and the principal-agent paradigm have been used to answer many research questions and solve problems in healthcare, yet their use for an organisational analysis collectively or separately is missing.

c) Research inquiries into the rule, system, and structure-based game theoretic organisation of healthcare service delivery by public hospitals are not found in the existing literature.

d) An integrated approach to research into public hospital outcomes by combining the delegation of authority, bureaucratic capacity and policy implementation is lacking.

This research study seeks to fill the gaps in the existing literature identified above and contribute to the body of knowledge in several ways. The rationale for undertaking this research as well as its contribution to knowledge are discussed next.

2.10 Rationale for this study

Emerging from the gaps identified by the literature reviewed in this chapter, the rationale for undertaking this study is as follows:

a) The lack of multiperspective and multitheoretical research has been identified by the literature review. This study uses an integrated (multiperspective and multitheoretical) approach to understand the organisation of healthcare service delivery by public hospitals.

b) The use of game theoretic modelling for organisational analysis has not drawn the attention of the researchers. Also, game theory and the three approaches to the organisation (of activities) belong to the research paradigms that can be viewed as poles apart. It integrates the two research paradigms for the organisation of healthcare service delivery.

c) By integrating game theory, public policy implementation and bureaucratic capacity, this study produces results of interest to researchers, practitioners, and policymakers.
d) To the best of the researcher's knowledge, this is the first game theoretic study for the organisation of healthcare service delivery (by public hospitals).

2.11 Summary of this chapter

The literature review indicated that there is glaring gap in the existing literature regarding a holistic understanding of healthcare service delivery. This study aims to fill this gap in the knowledge by theory integration, perspective integration and discipline integration. After having covered the theoretical groundwork in this chapter, the next chapter reviews the organisation of healthcare service delivery in Australia.

CHAPTER 3: ORGANISATION OF HEALTHCARE SERVICE DELIVERY IN AUSTRALIA

“While the Australian health system has many strengths, it is…under growing pressure, particularly as the health needs of our population change. We face significant challenges, including large increases in demand for and expenditure on health care, unacceptable inequities in health outcomes and access to services, growing concerns about safety and quality, workforce shortages, and inefficiency. …Public hospitals will be funded for the number and complexity of the patients they treat and rewarded for performance indicators including access, effective communication and clinical outcomes.” (Commonwealth of Australia 2009, pp. 3, 75)

3.1 Introduction

The literature review in chapter 2 highlighted the gaps in the existing knowledge. The three approaches of organising along with game theory, mechanism design theory and the principal-agent paradigm are the pillars on which the game theoretic model of this study stands. However, a clear understanding of the organisation or organising of healthcare service delivery in Australia is needed to add a practical context to the game theoretic model. Therefore, a sincere endeavour has been made in this chapter to critically evaluate the important aspects of the Australian healthcare system. Chapters 2 and 3 together also constitute the foundation of the conceptual framework of this study.

Section 3.2 lays out a description of the organisation of public healthcare in Australia and presents a comparison of public health expenditure and total health expenditure in similar healthcare systems - Australia, Canada and France and the funding mechanisms of public hospitals in Australia.

Section 3.3 presents a few health system performance indicators for Australia, Canada, and France.

Section 3.4 briefly compares the Australian, Canadian, and French health systems.

Section 3.5 discusses the role of public hospitals in Australia.

Sections 3.6 to 3.9 present the key aspects (hospital bed availability, waiting lists, appropriateness of healthcare delivery and average length of hospital stay) of healthcare service delivery.

Section 3.10 summarises this chapter and identifies four main problems facing the Australian healthcare system.

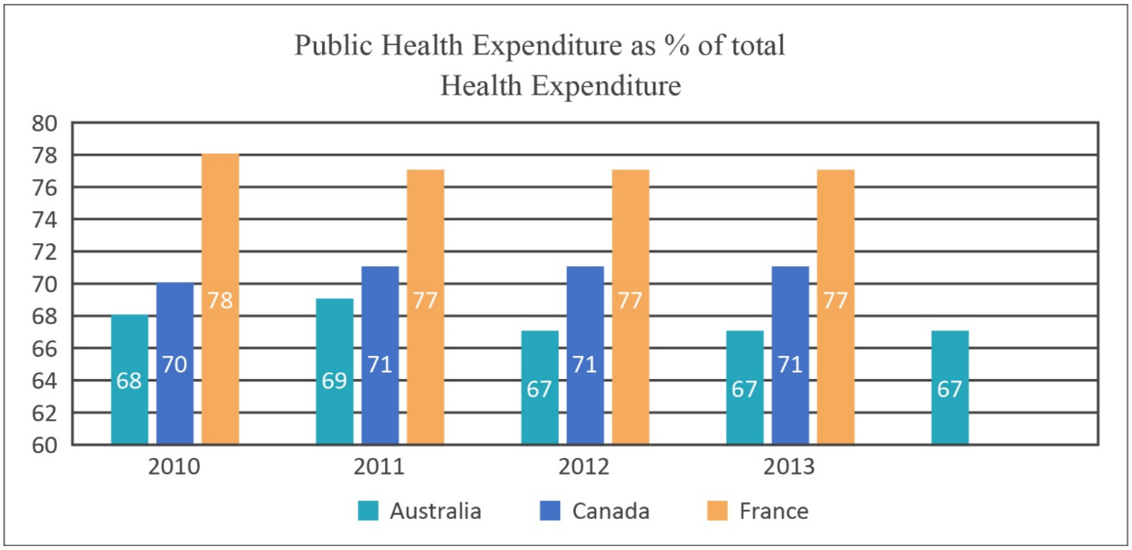
3.2 Organisation of public healthcare in Australia

There are three healthcare system models in the world, namely, the welfare state model, the market model and a mix of the welfare state and the market models – the hybrid model. In a welfare state model, healthcare is funded by tax dollars and the government assumes full responsibility for the provision of healthcare services. In a market model, the choice and payment of healthcare services is left to individual citizens and private institutions. In a hybrid model, the government provides public insurance for basic coverage, and individuals can buy private insurance for healthcare coverage on the top of any public insurance they have.

Australia has a hybrid healthcare system under which citizens, permanent residents and refugees can buy private insurance coverage in addition to the public insurance to gain access to both private and public hospitals (Willis & Parry 2016). The provision of healthcare services by the government requires some gate-keeping – the administration and approval of healthcare services – in some cases. Australia, Canada and France have similar healthcare systems because they provide public insurance for basic coverage and private insurance can be purchased by individuals (OECD 2010).

Australia had the lowest public health expenditure as a percentage of the total health expenditure, during the period 2010-2014 of these three countries with similar health systems. Public health expenditure as a percentage of total health expenditure in Australia, Canada and France is shown in Figure 3.1.

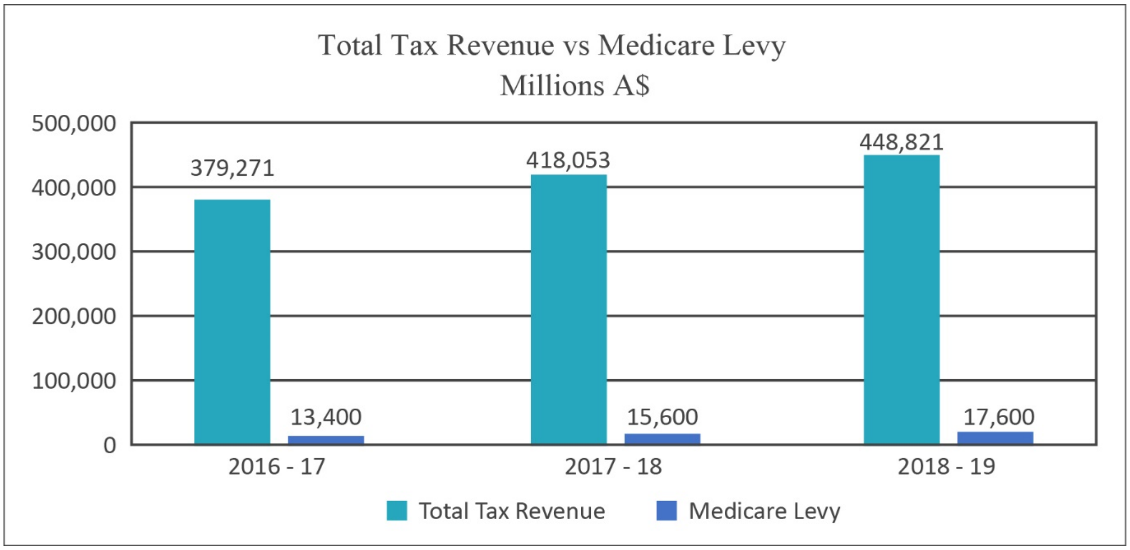
Figure 3.1 Public health expenditure as a percentage of total health expenditure during the period 2010-2014 (The World Bank 2017)



3.2.1 Public health insurance in Australia

The mandatory public insurance scheme in Australia, commonly known as Medicare, provides healthcare coverage to citizens, permanent residents, refugees, and citizens of a group of countries that have a reciprocal healthcare coverage agreement with Australia. Medicare is financed from tax dollars, by levying 2% of each person's income and a surcharge of 1% or 1.25% or 1.5% depending on the income of the individuals and families who have not purchased private insurance (ATO 2020). Medicare has two components, payments to public hospitals through the states and territories, and direct payments to doctors and some other health professionals (Willis & Parry 2016). Medicare is funded through taxation as well as the levy. As per the Australian government's budget outcomes for the years 2016-17 to 2018-19, the Medicare levy was respectively 3.53%, 3.73% and 3.92% of the total tax revenue – the corresponding data is shown in Figure 3.2.

Figure 3.2 Medicare levy as a percentage of total tax revenue during the years 2016-17 to 2018-19 as per the Australian government's budget outcomes (Commonwealth of Australia 2020)



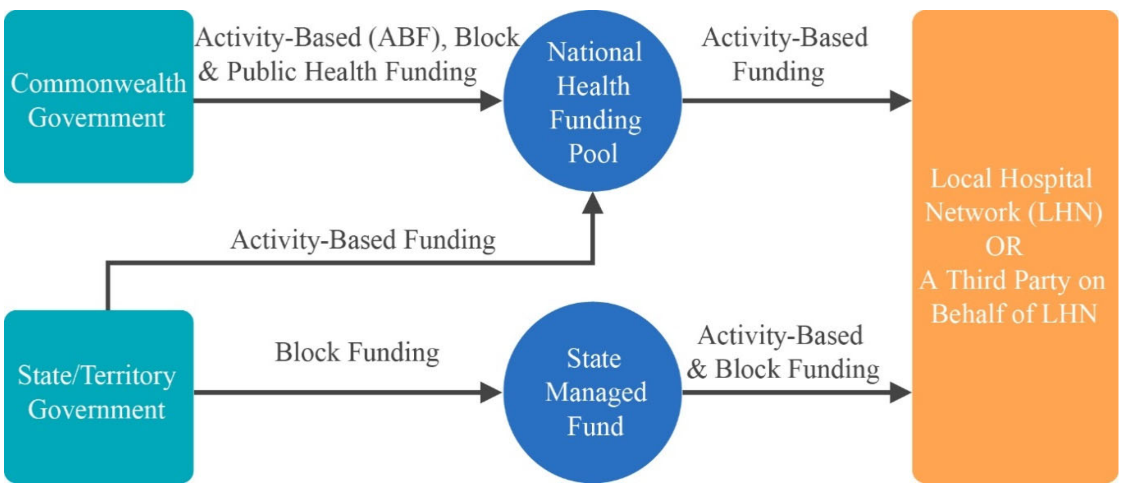
3.2.2 Public hospital funding in Australia

In August 2011, to bolster the sustainability of the public healthcare system, the Commonwealth and all the states and territories entered into the National Health Reform Agreement (NHRA) regarding the arrangements for the funding and management of public hospitals in Australia. The NHRA stipulates that the signatories are jointly responsible for providing funding to public hospitals, either as activity-based or block funding (CFFR 2011). The agreement was amended and renewed for the period 1 July 2020 to 30 June 2025 by way of an addendum (CFFR 2020). Public hospitals in Australia are reimbursed for services by using activity-based funding that depends on the number and cost of the services provided to patients. Block funding is provided for teaching and research (NHFB 2016). The NHRA sought to: (a) build a partnership between the Commonwealth, and all the states and territories; (b) recognize that the responsibility for the management of public hospitals lies with the states and territories; (c) ensure efficient pricing and improved patient access; (d) achieve the sustainability and transparency of public hospital funding, along with their accountability and responsiveness to local community needs; (f) ensure better performance by public hospitals;

and (g) achieve better healthcare outcomes (CFFR 2011).

During the years 2019-2020, the Commonwealth was to provide funding of not less than A$16.4 billion, with the rest of the funding coming from the states and territories, which are responsible for providing free healthcare in a timely manner (Willis & Parry 2016). It was also agreed that waiting periods for elective surgeries were to be made public. State and territory governments are responsible for: (a) healthcare delivery and planning by public hospitals, and their performance; (b) planning for funding, in collaboration with the Commonwealth for teaching, research and training; and, (c) state-wide public hospital industrial relations (CFFR 2011). A complete flowchart of public hospital funding is shown in Figure 3.3.

Figure 3.3 A flowchart of public hospital funding in Australia adapted from NHFB (2016)



3.3 Health system performance

A review of the Australian healthcare system reveals some interesting insights. Hospitals in Australia need to either increase their bed capacity or reduce the patients' length of stay or both because with regards to adults' access to healthcare, 10% of Australians had to wait for 4 months or more for elective surgery whereas only 4% of patients had to wait for elective surgery in France. There are concerns about the quality and adequacy of care that is being provided by the hospitals because 21% of patients had experienced a care coordination problem in the past two years. Similarly, 41% of patients reported gaps in hospital discharge planning in the past two years. Only 7% of patients experienced a care coordination problem in France. The public's view of the health system is also an area of concern as 48% percent of the public viewed the public health system as adequate, requiring only minor changes, and 43% saw a need for fundamental changes. A selected set of healthcare system performance indicators for Australia, Canada and France is shown in Table 3.1.

Table 3.1: Selected health system performance indicators for Australia, Canada and France adapted from Mossialos et al. (2016a) with modifications

Indicator		Australia	Canada	France
Adults' access to care, 2013	Waited 2 months or more for specialist appointment[a]	18%	29%	18%
	Waited 4 months or more for elective surgery[b]	10%	18%	4%
	Experienced access barrier because of cost in past year[c]	16%	13%	18%
Care coordination and transitions among older adults, 2014[f]	Experienced a coordination problem in past 2 years[d]	21%	32%	7%
	Experienced gaps in hospital discharge planning in past 2 years[e]	41%	44%	54%
Chronic care management among older adults, 2014[g,h]	Had a treatment plan they could carry out in daily life	80%	76%	62%
	Between visits, has health care professional they can contact to ask questions or to get advice	65%	67%	53%
Public views of health system, 2013	Works well, minor changes needed	48%	42%	40%
	Fundamental changes needed	43%	50%	49%
	Needs to be completely rebuilt	9%	8%	11%

Sources (unless noted otherwise): 2013, 2014, and 2015 Commonwealth Fund International Health Policy Surveys. **a:** Base: Saw or needed to see a specialist in past two years. **b:** Base: Needed elective surgery in past two years. **c:** Did not fill/skipped prescription, did not visit doctor with a medical problem, and/or did not get recommended care. **d:** Test results/medical records not available at time of appointment and/or doctors ordered medical test that had already been done; received conflicting information from different doctors; and/or specialist lacked medical history or regular doctor was not informed about specialist care. **e:** When discharged from the hospital: you did not receive written information about what to do when you returned home and symptoms to watch for; hospital did not make sure you had arrangements for follow-up care; someone did not discuss with you the purpose of taking each medication; and/or you did not know who to contact if you had a question about your condition or treatment. Base: hospitalized overnight in the past two years. **f:** Admissions resulting in transfer are included. **g:** Who had at least one chronic condition. **h:** Age 65 or older.

3.4 Comparison - Australia, Canada and France

Australia has a parallel private hospital system and its health policy encourages a robust public hospital system complemented by private hospitals, hence, patients may choose to go to a private or public hospital, however, the unsubsidised part of the private hospital's costs has to be covered by a private insurance plan (Esmail & MacKinnon 2013). The cost of seeking healthcare from a private hospital can be a barrier for those who do not have private insurance coverage or are not able to afford the costs from their own funds.

Canada has a mix of public and private hospitals including not-for profit. Ownership of hospitals rests with regional authorities or hospital boards from the community or the government (Allin & Rudoler 2014; Marchildon 2013). While healthcare organisation and delivery is primarily the responsibility of the provinces and territories, the federal government co-finances provincial and territorial health programs if such programs conform to the following five principles: (a) publicly administered; (b) comprehensive in coverage; (c) universal; (d) portable across provinces; and (e) accessible (Mossialos, Wenzl, Osborn & Sarnak 2016b).

The French healthcare system is driven by a strictly regulated ideological framework, but once patients are inside the framework, they are free to utilize healthcare as much as they want (Janus & Minvielle 2017). Physicians are autonomous, patients choose their physicians and have direct access to specialists. Healthcare services are provided by public hospitals, private not-for-profit hospitals, and the for-profit and the large ambulatory care sector (Allin & Rudoler 2014; Chevreul, Brigham, Durand-Zaleski & Hernández-Quevedo 2015; Steffen 2016). It has been suggested that an independent authority be created to coordinate hospital and ambulatory care, as the government currently controls these functions (Casassus 2017).

In France, employees and employers pay, for the most part, toward mandatory healthcare coverage for both themselves and their dependents through premiums which are based on a percentage of their gross wage. The statutory health insurance is funded by “employer and employee payroll taxes (64%); a national earmarked income tax (16%); taxes levied on tobacco and alcohol, the pharmaceutical industry, and voluntary health insurance companies (12%); state subsidies (2%); and transfers from other branches of the social security system (6%)” (Assurance Maladie 2015; Mossialos et al. 2016a, p. 59).

Australia uses activity-based funding (ABF) which has been scrutinised by researchers and experts. It is complicated due to the lack of rigorous empirical inquiries. Based on the information available, ABF increases the activity while reducing the length of stay and/or the hospital expenditure’s growth rate (Bouwstra, Wattel, de Groot, Smalbrugge & Hertogh ; O'Reilly, Busse, Häkkinen, Or, Street & Wiley 2012).

In Canada, though the provinces of Ontario, Alberta, and British Columbia have considered adopting an activity-based payment mechanism, the hospitals function under annual budgets negotiated with the provincial or territorial ministries of health or the regional health authorities (Mossialos et al. 2016b; Sutherland, Crump, Repin & Hellsten 2013; Sutherland, Repin & Crump 2014).

In France, the payment to healthcare service providers is based on a diagnosis-related group (DRG) system. Patients are reimbursed the cost they incur minus the co-payments.

While ABF drives activities to meet particular targets, such as emergency room waiting times, block funding promotes cost controls (Collier 2008), so a switch to ABF may affect post-acute care admissions and create uncertainty around its impact on other critical outcomes (Palmer, Agoritsas, Martin, Scott, Mulla, Miller, Agarwal, Bresnahan, Hazzan & Jeffery 2014).

A summary of the key characteristics of the Australian, Canadian and French healthcare systems is shown in Table 3.2.

Table 3.2: A comparison of health systems – Australia, Canada and France

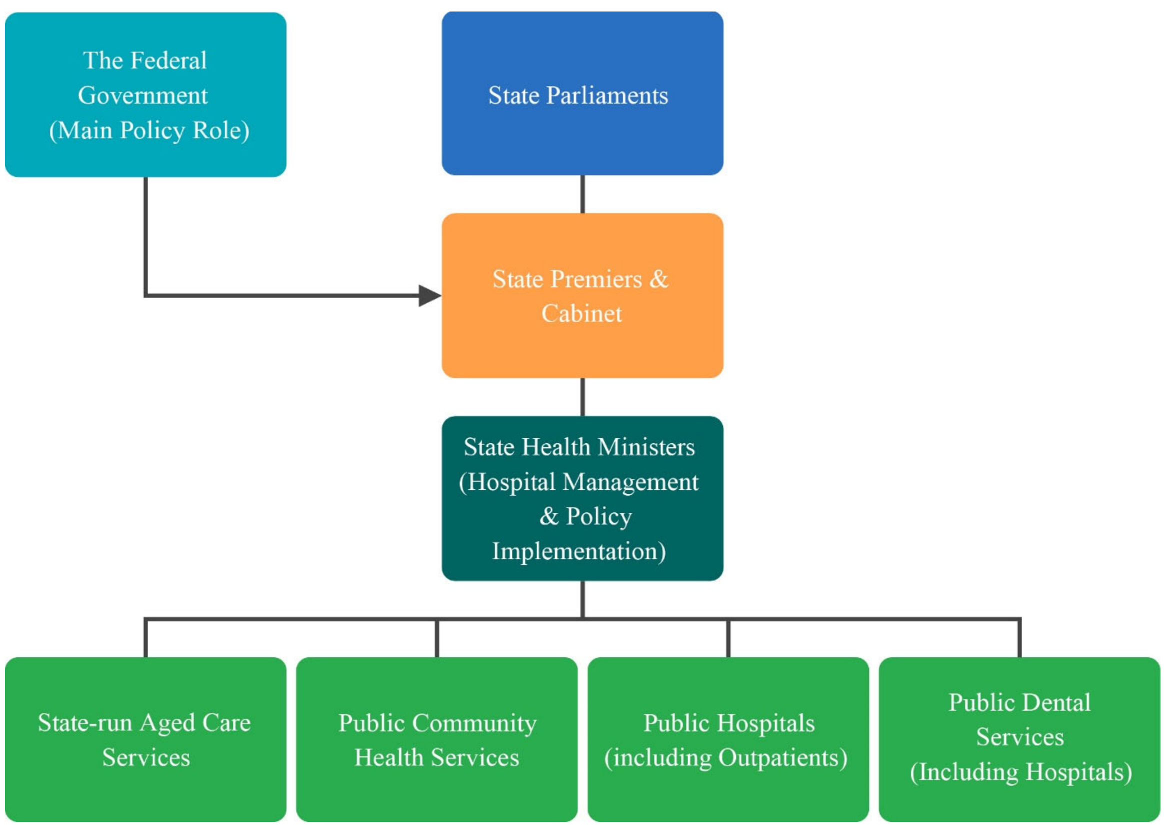
Criteria	Australia	Canada	France
Responsibility to provide healthcare	Federal, state and territory governments	Provinces and territories	Universal coverage
Hospital-type	Both public and private	A mix of public and private hospitals including not-for profit	Mostly public and not-for-profit
Financing	Both governments and private insurance providers	Provinces and territories with co-financing by the federal government if set criteria is met, and private health insurance	Employer and employee payroll taxes, other taxes and levies
Reimbursement mechanism	Activity-based for public hospitals; and co-payments, deductibles, exclusions, and restrictions	Hospitals' annual budgets are negotiated with the provincial and territory governments, and private health insurance	A diagnosis-related group (DRG) system for the hospitals; and reimbursements to patients minus the co-payments
Barriers	Cost is a barrier to use private hospitals	Cost is a barrier to use the services not covered	Patients are free to choose primary care physicians and specialists

3.5 Public hospitals in Australia

As per the 2017-18 data, there were a total of 1,350 hospitals in Australia, of which 693 were public and 657 were private. As of June 2019, Australia's total population was 25.4 million. During 2017-18, the recurrent expenditure on public hospitals was A$71 billion. There were 11.2 million hospital admissions during the year 2017-18, of which 6.7 million admissions (83% of these were public patients, the remaining 17% separations were funded by other sources) were in public hospitals whereas 4.5 million admissions were in private hospitals (AIHW 2019). Simply put, public hospitals handled about 60% of the total admissions during the year 2017-18.

The formulation of health policies governing public hospitals rests with the Commonwealth. State or territory governments are entrusted with the responsibility of implementing health policies while sharing the costs with the Commonwealth. Public hospitals are required to follow the quality and performance mechanisms established by the federal government in consultation with the state and territory governments. The overall position of public hospitals within the Australian healthcare system is shown in Figure 3.4.

Figure 3.4 Public hospitals as a part of the Australian public healthcare system adapted with modification from Mossialos et al. (2016a)



The Department of Health and Human Services (DHS), Victoria has outlined the following indicators for acute care services: (a) percentage of patients seen within clinically recommended times; (b) safe and high quality of healthcare services; (c) more patients within out-of-hospital settings; (d) focus on patient experience; (e) healthcare investments; (f) sustainable workforce; (g) reduced hospitalisation for ambulatory care; and, (h) sustainable infrastructure (State of Victoria 2016b). A focus on patient experience is no surprise, as in the fast-changing healthcare sector, hospitals use various strategies to involve patients in the provision of care with a goal of implementing innovations. Patient-centred strategies are those that seek to involve patients in the delivery of high quality, effective and safe healthcare as per the patients' needs (Coulter & Ellins 2007).

3.6 Public hospital service delivery - Hospital bed availability

The number of beds available per 1,000 people in Australia was 3.8 in 2016. The same numbers for Canada and France were 2.5 and 6 respectively in 2017. High occupancy rates of curative (acute) care beds could be an indication of a health system which could lead to deterioration in quality and bed shortages (OECD 2019). However, the hospital acute bed occupancy data for Australia is not available. The quarterly average hospital bed days for Victoria were 1,319,803 during the period July 2019 to June 2020 (State of Victoria 2020). Furthermore, the data for 2011-12 to 2014-15 revealed that Victoria remained behind the average for Australia with regard to available hospital beds per 1,000 persons in the population (Commonwealth of Australia 2015).

3.7 Public hospital service delivery - Waiting lists

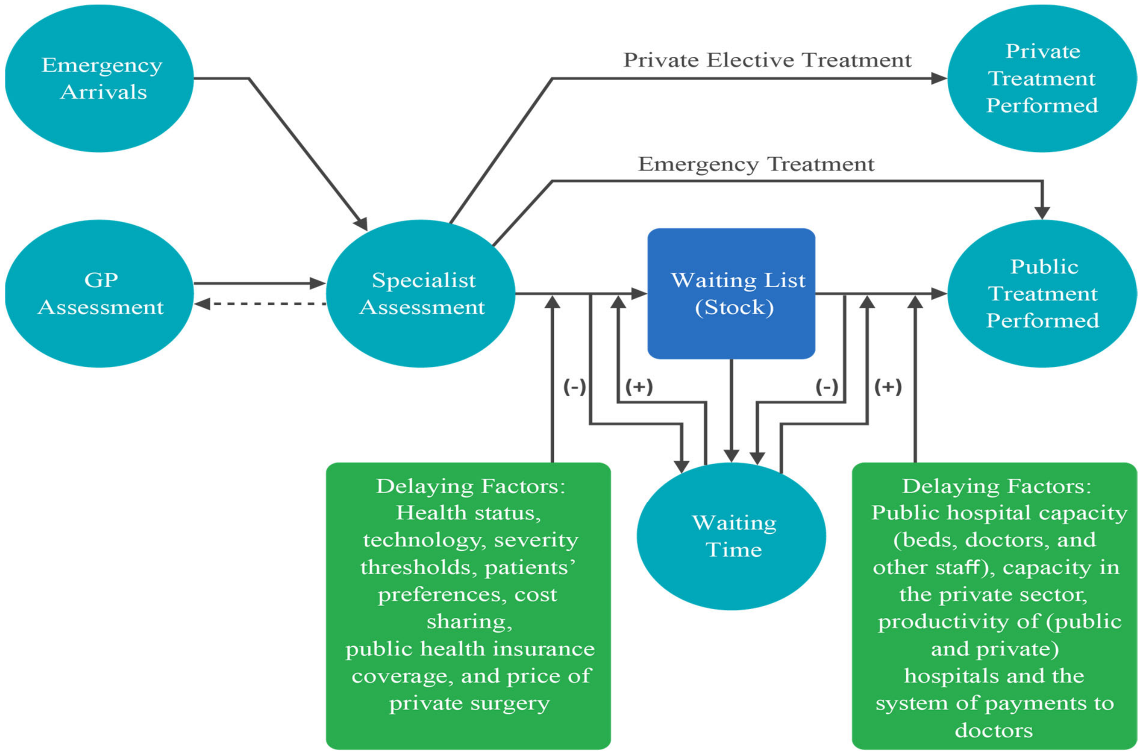
In simple terms, waiting lists represent some patients who must wait – due to capacity limitations - to get treatment as prescribed by a specialist. In a healthcare system funded by a government, waiting lists have several implications: (a) long waiting lists create a policy headache for politicians due to the unpopularity of these lists; (b) many patients may not wait their turn and seek treatment from private hospitals; (c) waiting lists are costly to administer;

and (d) waiting lists may point to the underutilisation of available hospital beds (Siciliani, Borowitz & Moran 2013).

There are two categories of waiting times for publicly funded patients: (i) waiting times from a specialist's assessment for a patient to receive treatment, and (ii) waiting times of patients who are on the list for a procedure. Waiting times do not include the period from the date of a general practitioner's referral to the date of a specialist's assessment. Waiting times are measured in three units, namely, the mean days that patients have been waiting for the procedure, the median days separating evenly the higher and lower half of patients who have waited for the longest time and the least number of days and the percentage of all patients waiting for more than three months (OECD 2020).

GPs refer patients to specialists who, after making an assessment, decide whether to return a patient to the GP for on-going treatment, or recommend a procedure. If a procedure is recommended for a patient, he or she is added to a waiting list. A range of factors including the severity of the condition and the cost of private treatment add to the waiting lists. Other factors such as the availability of hospital beds, the physicians' payment systems and their productivity shorten the waiting lists. A conceptual design of the process and the factors that shape the waiting lists, as suggested by Siciliani and Hurst (2005), is are shown in Figure 3.5.

Figure 3.5: Framework of waiting lists and waiting times for elective treatment adapted from Siciliani and Hurst (2005) with modifications



In terms of waiting lists in median days, from 2011-2014, Canada fared better than Australia in four surgery categories: cataract surgery, coronary bypass surgery, hip replacement and knee replacement (OECD 2020) as shown in Figures 3.6 and 3.7.

Figure 3.6: Waiting time (in median days) from specialist assessment to treatment for cataract and coronary bypass surgery for Australia and Canada (OECD 2020)

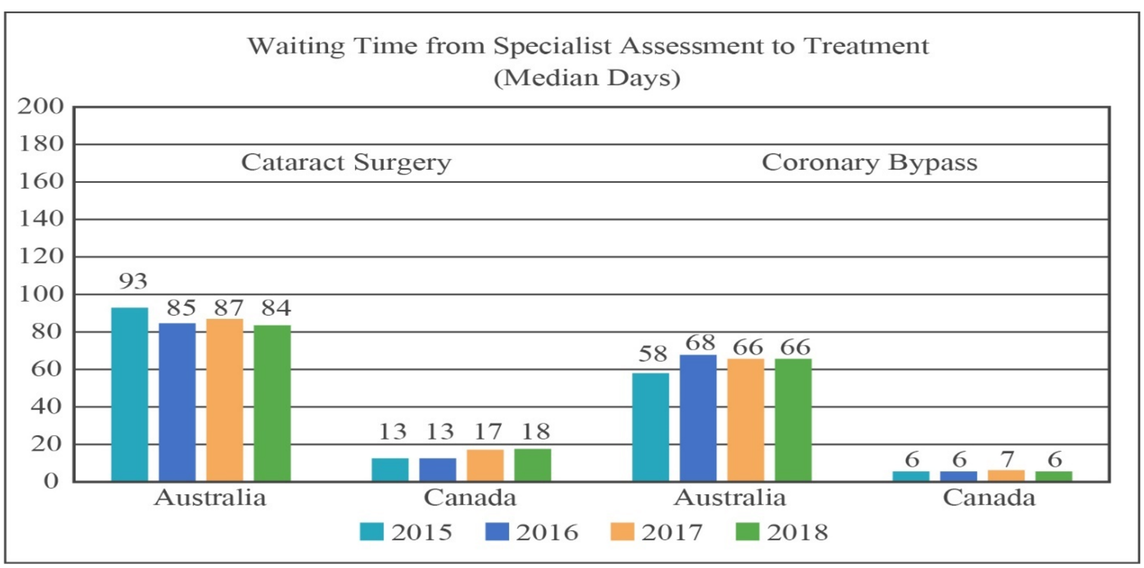
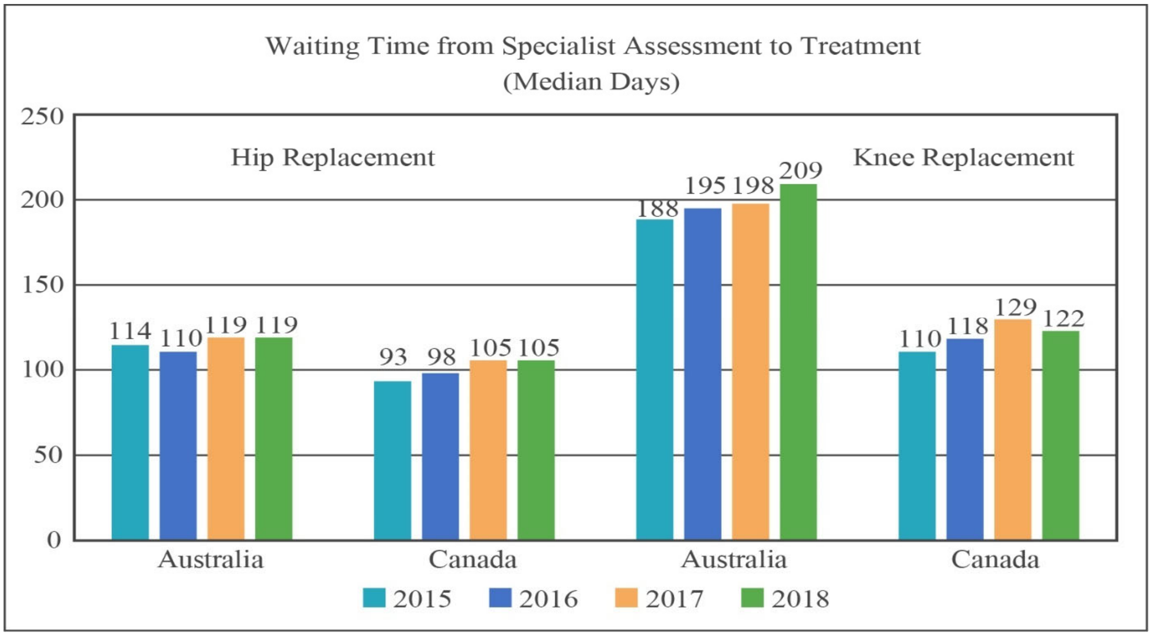


Figure 3.7: Waiting time (in median days) from specialist assessment to treatment for hip and knee replacement surgery for Australia and Canada (OECD 2020)



Victorian elective surgery waiting times by clinical urgency category, public hospitals (per cent) are shown in Table 3.3.

Table 3.3: Victorian elective surgery waiting times by clinical urgency category, public hospitals (per cent) adapted from Commonwealth of Australia (2015) with modification.

	2011-12	*2012-13*	*2013-14*	*2014-15*	*2015-16*
Per cent of patients on waiting lists with extended waits					
Category 1 (over 30 days)	–	–	–	–	–
Category 2 (over 90 days)	34.0	37.5	34.7	32.3	28.2
Category 3 (over 12 months)	9.4	17.0	14.0	7.8	7.3
All patients	20.6	26.4	23.8	19.6	16.9
Per cent of patients admitted from waiting lists with extended waits					
Category 1 (over 30 days)	–	–	–	–	–
Category 2 (over 90 days)	27.7	34.3	31.4	24.2	22.9
Category 3 (over 12 months)	8.5	11.0	9.9	7.4	6.3
All patients	14.9	18.4	17.3	13.0	12.1
Waiting time data coverage					
Per cent of elective surgery separations	78.9	79.0	79.6	79.5	80.7

3.8 Public hospital service delivery - Appropriateness

A widely disseminated study, called the CareTrack study, was conducted in Australia by Runciman et al. (2012) to determine the appropriateness of healthcare delivery as a result of patients' encounters with healthcare professionals including GPs, specialists and physiotherapists. Some of the health conditions chosen for the CareTrack study were taken from a seminal study in the United States by McGlynn, Asch, Adams, Keesey, Hicks, DeCristofaro and Kerr (2003). The CareTrack study revealed that significant improvements were needed to deliver appropriate healthcare in Australia. The results of the selected health conditions covered by the CareTrack study are shown in Table 3.3.

Table 3.4: Numbers of indicators, participants and eligible encounters, and percentage of encounters at which appropriate care was received, by condition, 2009–2010 adapted with modifications from Runciman et al. (2012).

Condition	No. of Indicators	No. of Participants	No. of Eligible Encounters	No. of Encounters with Appropriate Care (95%CI)
Coronary artery disease	38	131	769	90% (85.4%–93.3%)
Chronic heart failure	42	30	541	76% (65.1%–85.1%)
Osteoporosis	14	60	387	55% (20.8%–86.3%)
Atrial fibrillation	18	59	242	55% (46.9%–62.8%)
Cerebrovascular accident	35	19	290	53% (38.2%–67.7%)
Osteoarthritis	21	188	3,517	43% (35.8%–50.5%)
Preventive care	13	665	2,366	42% (31.4%–53.6%)
Surgical site infection	5	348	721	38% (27.9%–48.6%)
Chronic heart failure	42	30	541	76% (65.1%–85.1%)

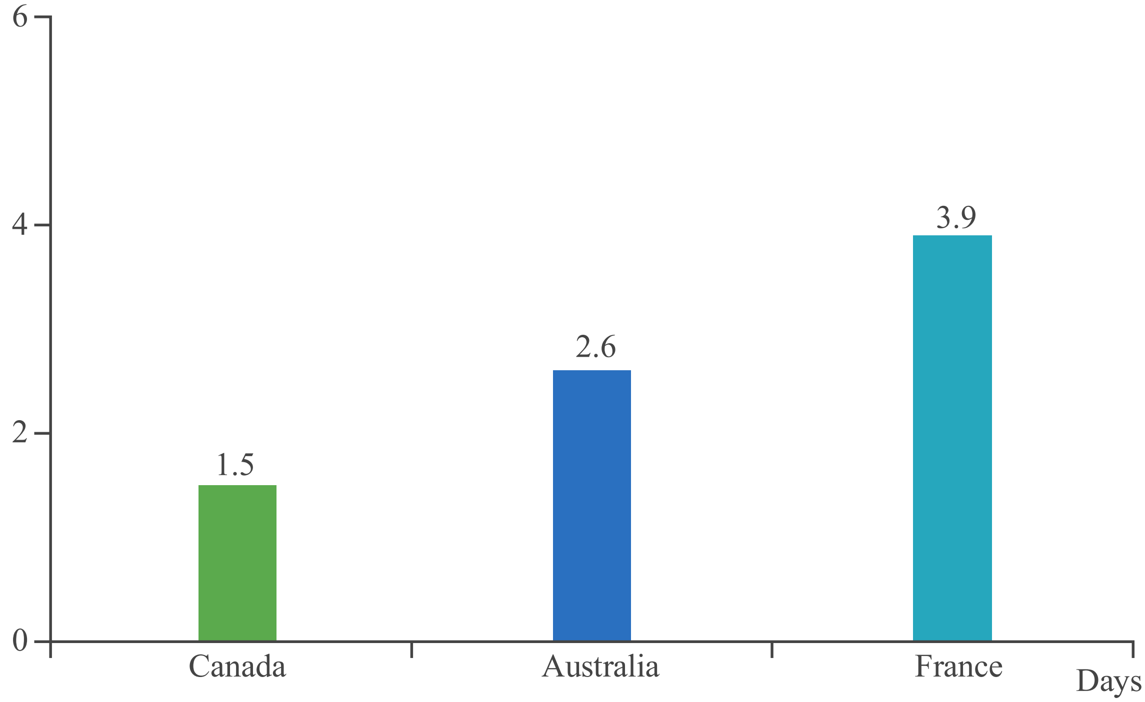
3.9 Public hospital service delivery – Average length of stay

A shorter hospital stay for patients has several implications. First, it reduces the cost of hospitalisation per patient and shifts the care from acute settings to post-acute settings. Second, a longer stay may be an indicator of poor quality (e.g., inefficient processes, errors, delayed recovery time, poor care coordination and readmissions due to post-discharge complications). Third, longer stays keep the beds occupied, and as a consequence, patients in need of treatment may have to wait longer. Fourth, a longer length of stay may be an indicator of the lack of good quality post-acute healthcare services. Last, discharging patients too early may have a negative impact on their outcomes (OECD 2017). As per OECD (2019, p. 196):

"Average length of stay refers to the average number of days patients spend in hospital. It is generally measured by dividing the total number of days stayed by all inpatients during a year by the number of admissions or discharges. Day cases are excluded. Data cover all inpatient cases (including not only curative/acute care cases) for most countries, with the exceptions of Canada, Japan and the Netherlands, where data refer to average length of stay for curative/acute care or in acute care hospitals only (resulting in an under estimation). Healthy babies born in hospitals are excluded from hospital discharge rates in several countries (e.g., Australia, Austria, Canada, Chile, Estonia, Finland, France, Greece, Ireland, Lithuania, Luxembourg, Mexico and Norway), resulting in a slight overestimation of the length of stay (e.g., the inclusion of healthy newborns would reduce the average length of stay by 0.5 days in Canada). These comprise around 3-10% of all discharges. Data for normal delivery refer to ICD-10 code O80, and for AMI to ICD-10 codes I21-I22."

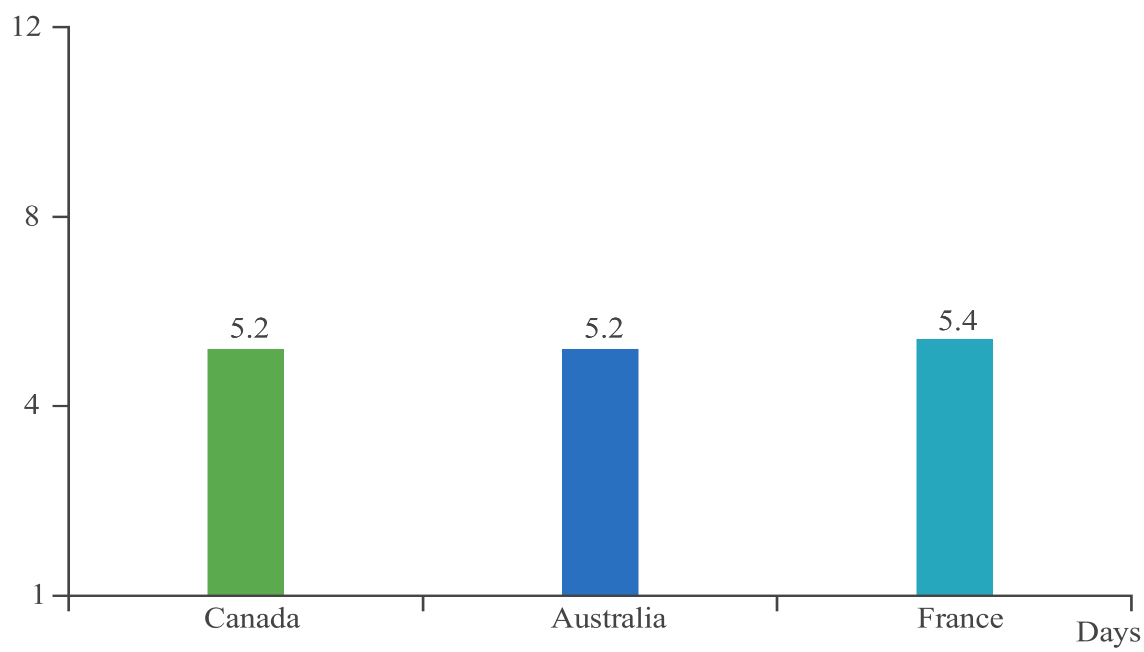
Limited ALOS data for Australia is available with the OECD in regard to different health conditions. For the year 2017, Australian, Canadian and French ALOS data for normal delivery are shown in Figure 3.8. Australia has an ALOS of 2.6 days, while Canada stands at 1.5 days.

Figure 3.8: Average length of stay for normal delivery for 2017 (or nearest year) adapted from OECD (2019)



For the year 2017, Australian, Canadian and French ALOS data for acute myocardial infarction (AMI) is shown in Figure 3.9. Canada and Australia both have ALOS of 5.2 days.

Figure 3.9: Average length of stay for acute myocardial infarction (AMI) for 2017 (or nearest year) adapted from OECD (2019)



3.10 Summary of this chapter

A review of the Australian healthcare system in this chapter has served three purposes: (a) the issues and problems identified in this chapter and the findings of the literature review together are the foundation of the conceptual framework presented in the next chapter; (b) this chapter provides the context of this research so that the reader can understand how the players, their strategies and other elements of the game theoretic model are developed; and (c) since this study uses policy implementation status for game theoretic modelling, a review of the Australian healthcare system highlights the status of health policy. The following issues or problems have been identified by the review of the Australian public healthcare system:

3.10.1 Issue or problem 1

Australia's public health outlay, as a percentage of its total health expenditure, was lower in comparison to that of Canada and France. It can be argued that the policymakers have some flexibility to boost public health spending by redesigning healthcare service delivery to improve performance (Section 3.2). <u>*Thus, a policy implementation status model would be more practical if it includes financial performance improvement.*</u>

3.10.2 Issue or problem 2

There is a need to critically review the Australian healthcare system in comparison to the Canadian and French health systems in regard to a reimbursement mechanism and cost barriers to access (Section 3.31). Australia uses activity-based funding, and thus there is scope for switching to a bundled payment system in which efficiency, quality and patient outcomes are rewarded. Bundled payment models reduce costs without hampering the quality of care (Siddiqi, White, Mistry, Gwam, Nace, Mont & Delanois 2017). In a bundled payment mechanism, the payment for services is not only fixed, but is also subject to quality and patient outcomes. <u>*Thus, a policy implementation status model would be more practical if hospitals are rewarded for financial savings, quality care and patient satisfaction.*</u>

3.10.3 Issue or problem 3

Hospitality bed availability is good in Australia. However, the data for bed occupancy is not available. It is not possible to ascertain whether the Australian healthcare system is under pressure. However, Australian public hospitals need to reduce the wait times for elective surgery (Section 3.7). There are two main issues related to the waiting lists for elective surgeries: (a) the time lost between a GP's recommendation and a specialist's assessment is important; and (b) waiting lists may be an indication of inadequate resource allocations or the underutilisation of the available resources. The availability of beds in hospitals, wait times for surgeries and average length of stay are related and interdependent issues. *Thus, a policy implementation status model would be more practical if public hospitals are rewarded for reducing the average length of stay because a reduced average length of stay would also free up beds that can be used to shorten the wait lists.*

3.10.4 Issue or problem 4

In addition, a lack of appropriate care remains a big problem in Australia (Section 3.8). *Thus, a policy implementation status model would be more practical if hospitals are rewarded for improving the quality of care and patient satisfaction.*

After having identified the gaps in the existing literature (chapter 2) and the issues that are encountered by the Australian healthcare system (chapter 3), the next chapter presents the two game theoretic models of policy implementation status.

CHAPTER 4: GAME THEORETIC MODEL FOR THE ORGANISATION OR ORGANISING OF HEALTHCARE SERVICE DELIVERY BY PUBLIC HOSPITALS

"… if we do not take steps in the direction of adding a solid empirical base to game theory, but instead continue to rely on game theory primarily for conceptual insights (deep and satisfying as these may be), then it is likely that long before a hundred years game theory will have experienced sharply diminishing returns… However my optimism that in the future we will see more empirical work pointedly directed at theoretical issues is based on the fact that work of this sort has already begun to thrive." (Roth 1991, p. 108)

4.1 Introduction

Chapter 2 provided the theoretical foundations of this research study. Chapter 3 not only highlighted the issues or problems of public hospitals in Australia, it also underlined the context of this research study. A context can be defined as circumstances that facilitate the formation of an event or idea as well as its understanding (Lexico 2020). Therefore, context is critically important for the generalisation of a research study's findings (George, Scott, Garimella, Mondal, Ved & Sheikh 2015; Polit & Beck 2010). While the conceptual framework of this study is a visual representation of the relationships of the concepts, ideas and theories (Maxwell 2005) in relation to the research problem (Ravitch & Riggan 2016), the context of this research study is healthcare service delivery by public hospitals in Australia.

Section 4.2 presents the justification for using a multiperspective and multitheoretical research paradigm.

Section 4.3 describes the theoretical and conceptual foundations of this research study.

Section 4.4 explains the justification for choosing average length of stay (ALOS) for the game theoretic organisation of healthcare service delivery.

Section 4.5 describes the research methodology and data sources.

Section 4.6 explains the application of policy implementation and bureaucratic capacity to public hospitals in relation to the organisation of healthcare delivery.

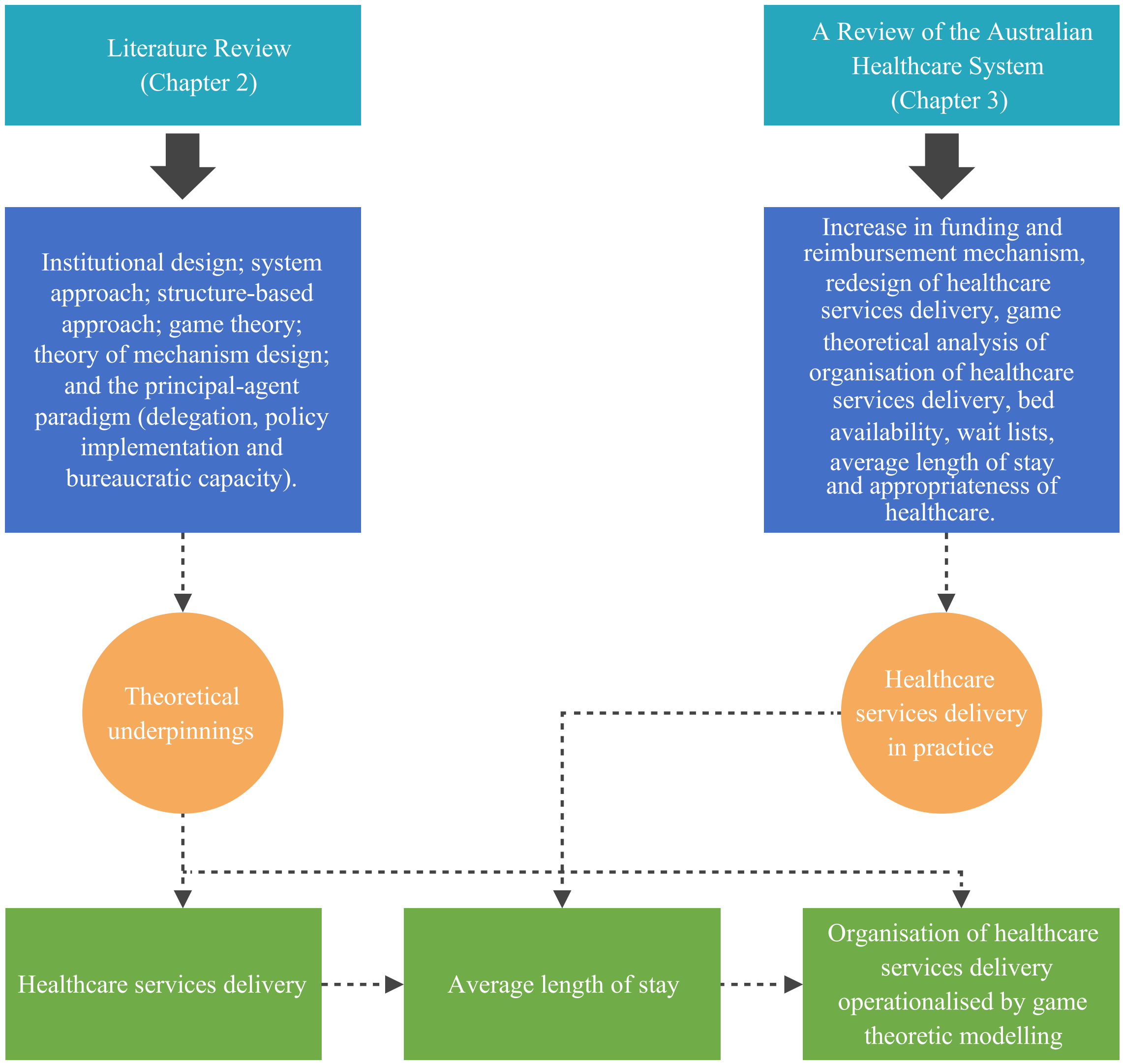
Section 4.7 presents the game theoretic model including the environment of the game, players, strategies, payoffs, and algorithms.

Section 4.8 summarises this chapter.

4.2 Justification for using a multiperspective and multitheoretical research paradigm for the model

A model based solely on game theory puts the onus on a researcher to describe the environment of a game, make assumptions regarding players' interactions and then decide what the payoffs for each player could be. Even then, it would miss the theoretical and practical evidence as to what organising is and how healthcare services are delivered. Therefore, both the multiperspective and multitheoretical nature of this study and the game theoretic model have the best of both worlds (theory and practice). An overview of the foundations of the game theoretical model of this study is presented in Figure 4.1.

Figure 4.1: An overview of the game theoretical model



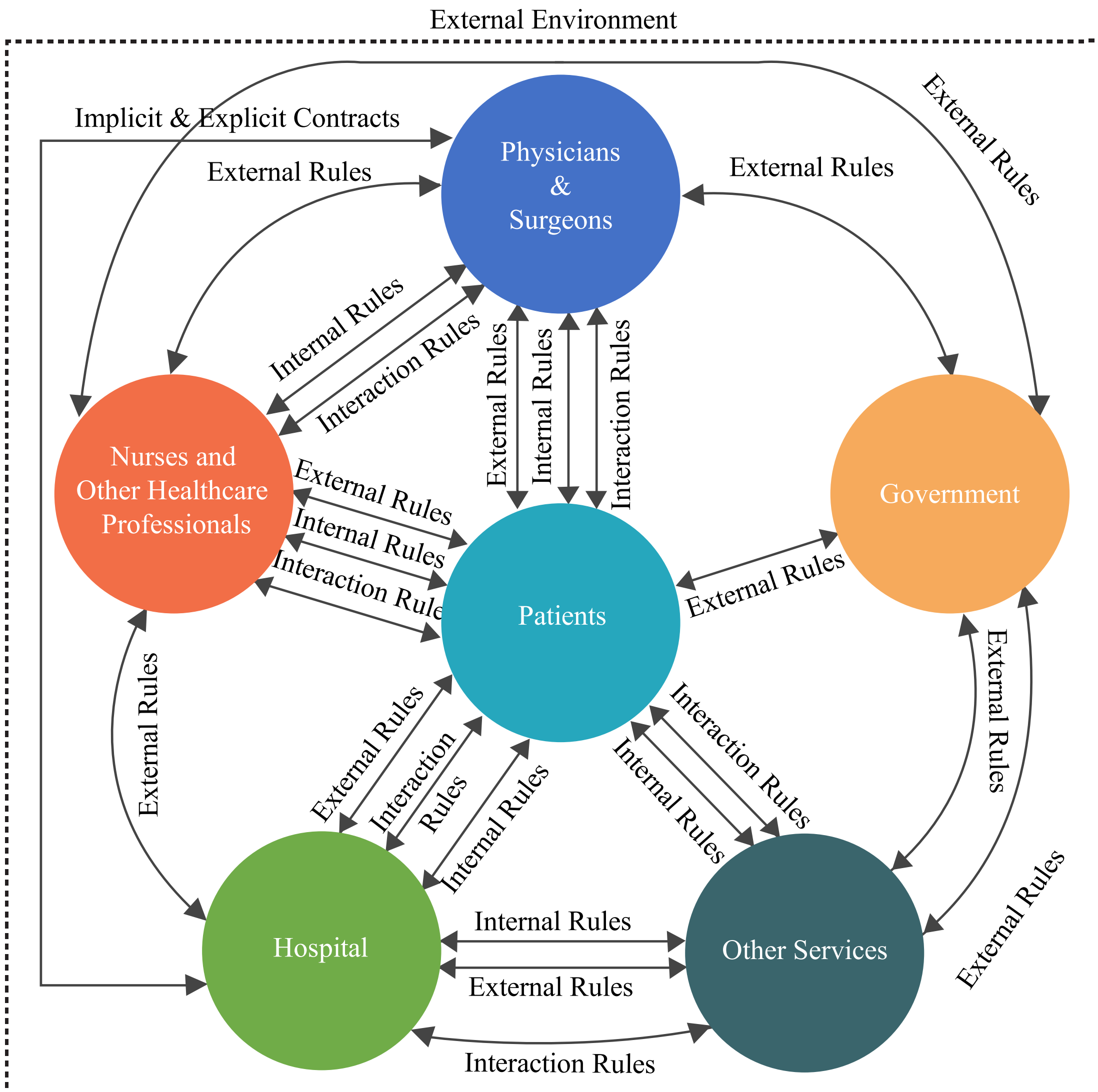
4.3 The theoretical and conceptual foundations of the model

The theoretical and conceptual foundations of the model presented in this chapter can be divided into two parts: (a) organisation of healthcare service delivery underpinned by the three approaches (institutional design, system thinking and structure-based organising) and game theory, the theory of mechanism design and the principal-agent paradigm (delegation, policy implementation and bureaucratic capacity) explicated in chapter 2; and (b) the issues and problems of Australian healthcare systems (specifically public hospitals) discussed in chapter 3.

4.3.1 A multiperspective public hospital organisation based on the three approaches – institutional design, system approach and structure-based approach

If one has to apply institutional design approach to the organisation or organising of healthcare service delivery by public hospitals, two conditions must be present: - (a) there must be individuals and groups that collaborate to achieve their collective goals by following a system or mechanism of rules (Goodin 1998; Hodgson 2006) – public hospitals meet this condition because healthcare services are delivered by multidisciplinary teams of professionals by following rules, regulations, laws, clinical protocols and rule-based mechanisms; (b) there must be an enforcement mechanism to shape or guide interactions (among healthcare delivery professionals and teams), and for this purpose, incentives or disincentives may have to be instituted (Meessen et al. 2006). Public hospitals meet this condition because not only rules, regulations, laws, and clinical protocols exist, they are also enforced both internally (clinical governance) and externally (government regulations and accreditation). *In the context of game theory, players' strategic interactions are subject to institutional design.* Thus, the organisation of healthcare service delivery based solely on institutional design can be visualized as shown in Figure 4.2

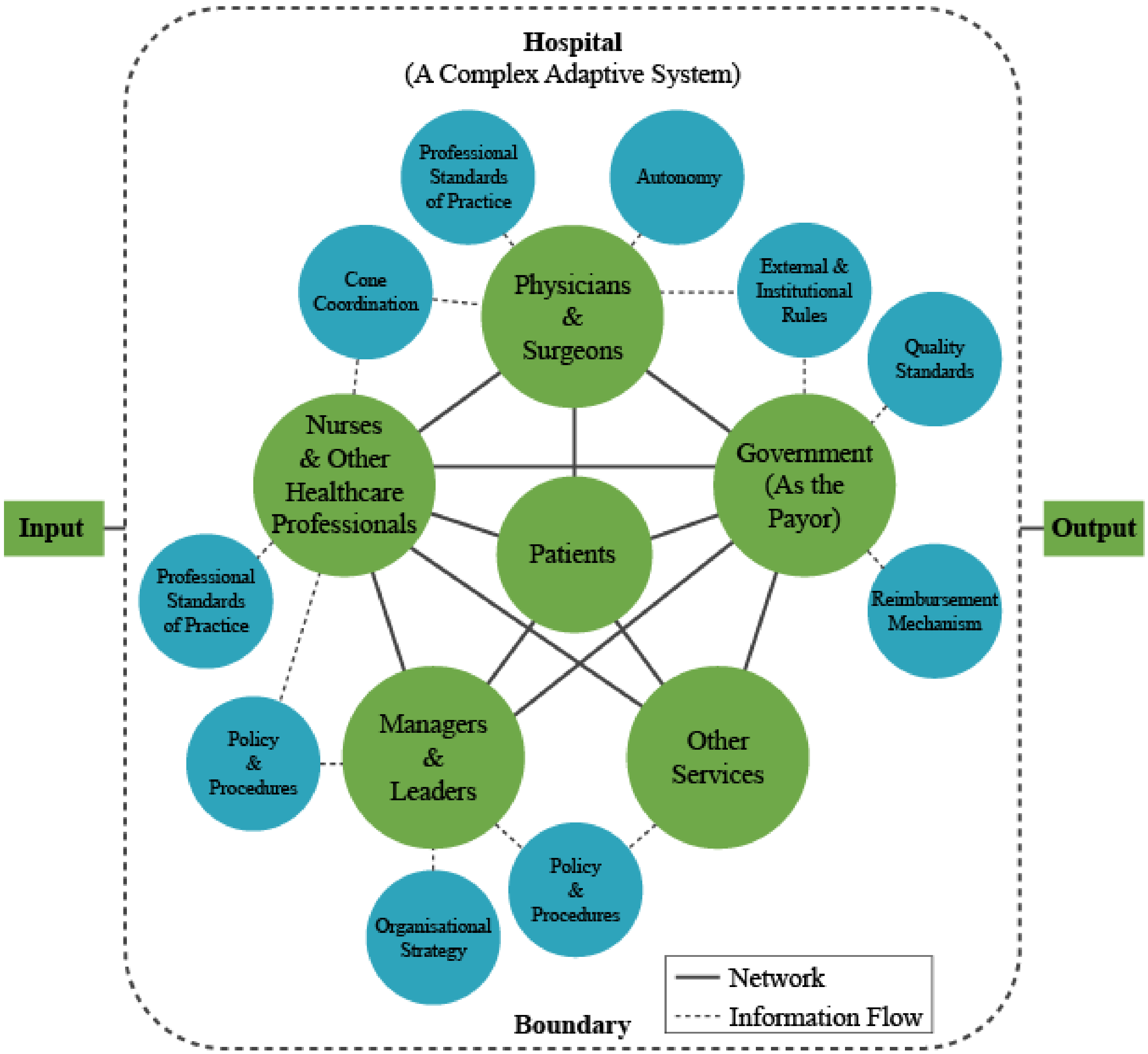
Figure 4.2: Organisation of healthcare service delivery based on institutional design



Internal Rules: Organisational policies, procedures, code of professional practice and clinical pathways.
External Rules: Laws, regulations and reimbursement rules.
Interaction Rules: Implicit and explicit contracts, social norms, patient-centredness and value-based care.

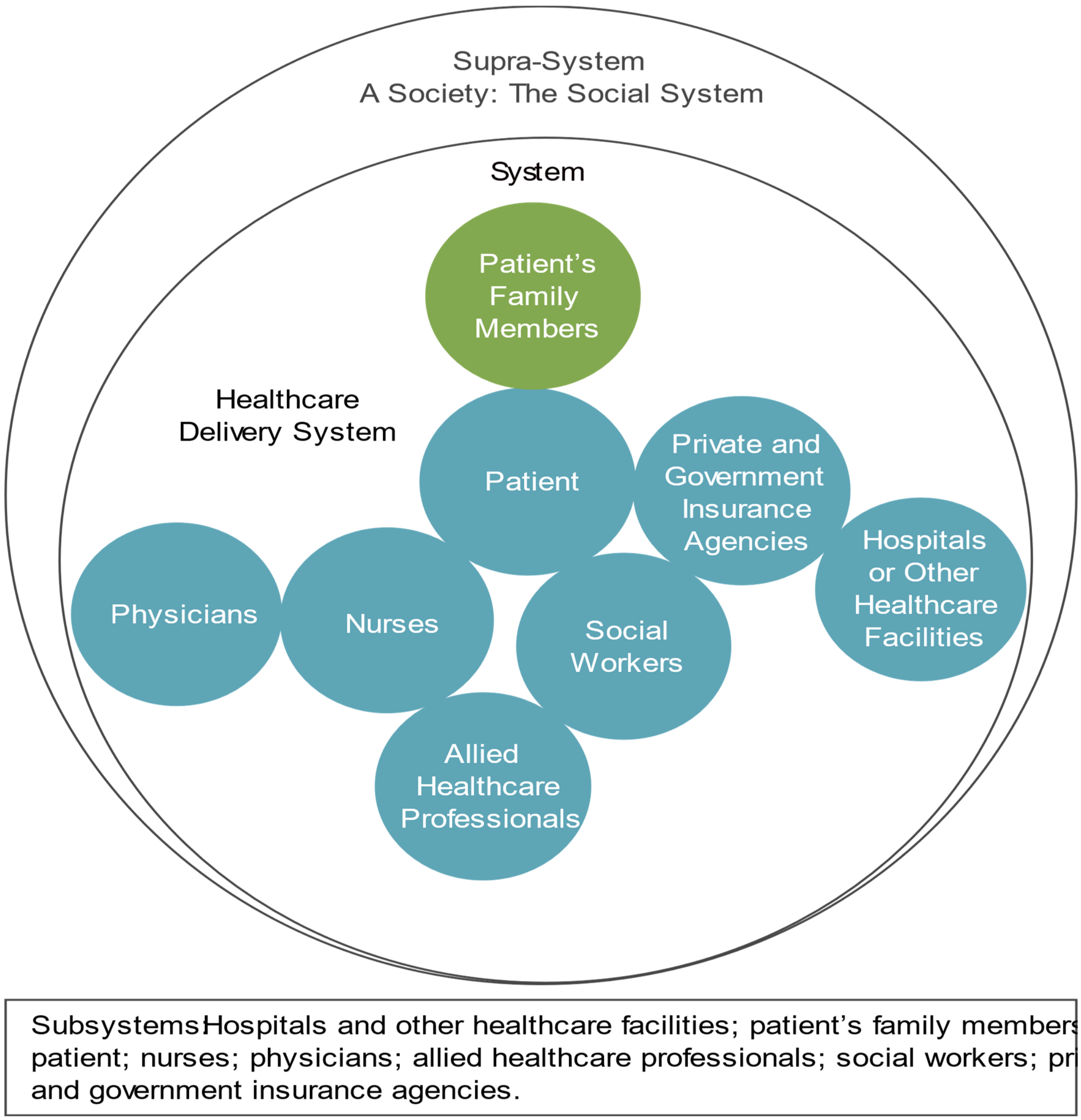
As Ackoff (1981) clearly indicated, organisations are complex open systems with many interdependent subsystems, including a process of social cognition that facilitates an understanding of an organisation (a system) relationship with its environment driven by procedural and practice-based rules (Magalhaes 2011). In public hospitals, multidisciplinary healthcare professional teams collaborate to deliver healthcare services to patients. Hence, a hospital (a system) can be viewed as a combination of four interdependent subsystems – patients, healthcare delivery teams, organisation (healthcare delivery teams and others, relationships and both rule-based and other interactions) and environment (Cordon 2013) for quality in healthcare service delivery (Chuang & Inder 2009). *In the context of game theory, players' strategic interactions are shaped by system thinking.* The organisation of healthcare service delivery based solely on system thinking can be visualized as shown in Figure 4.3

Figure 4.3: Organisation of healthcare service delivery based on system thinking



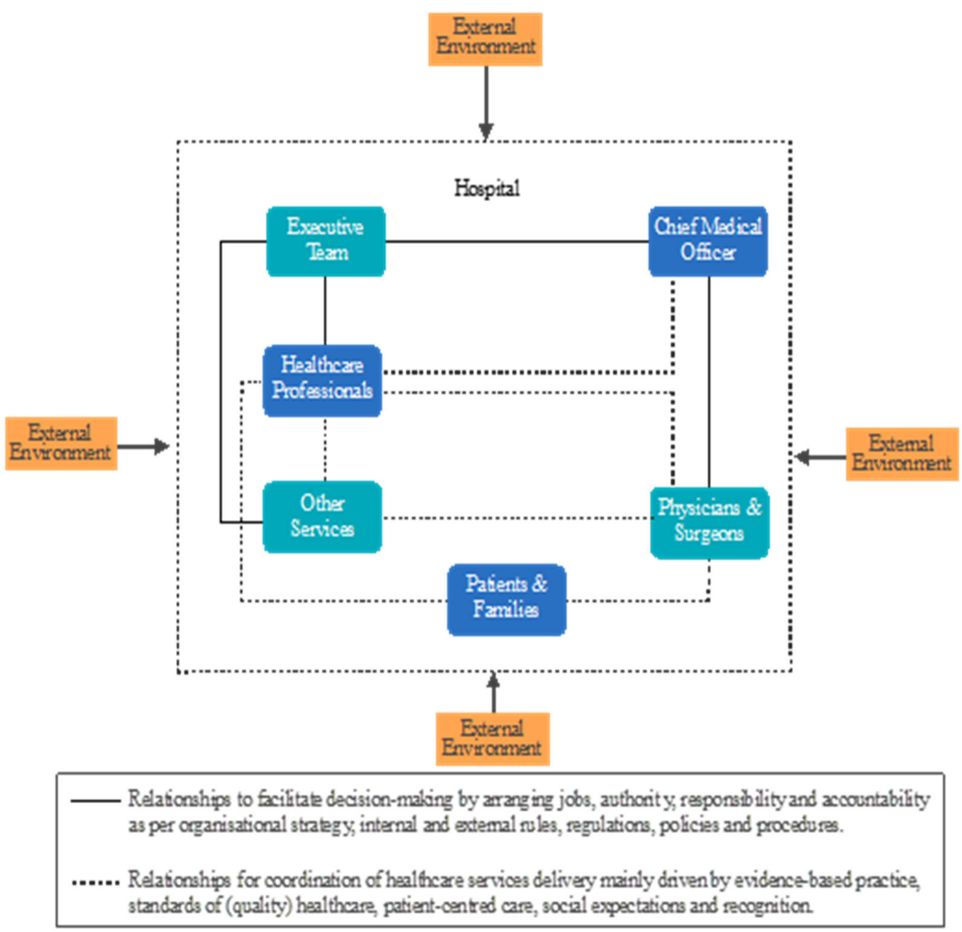
Alternatively, a system-based organisation of healthcare services can also be viewed as shown in Figure 4.4.

Figure 4.4: An alternative organisation of healthcare service delivery based on system thinking



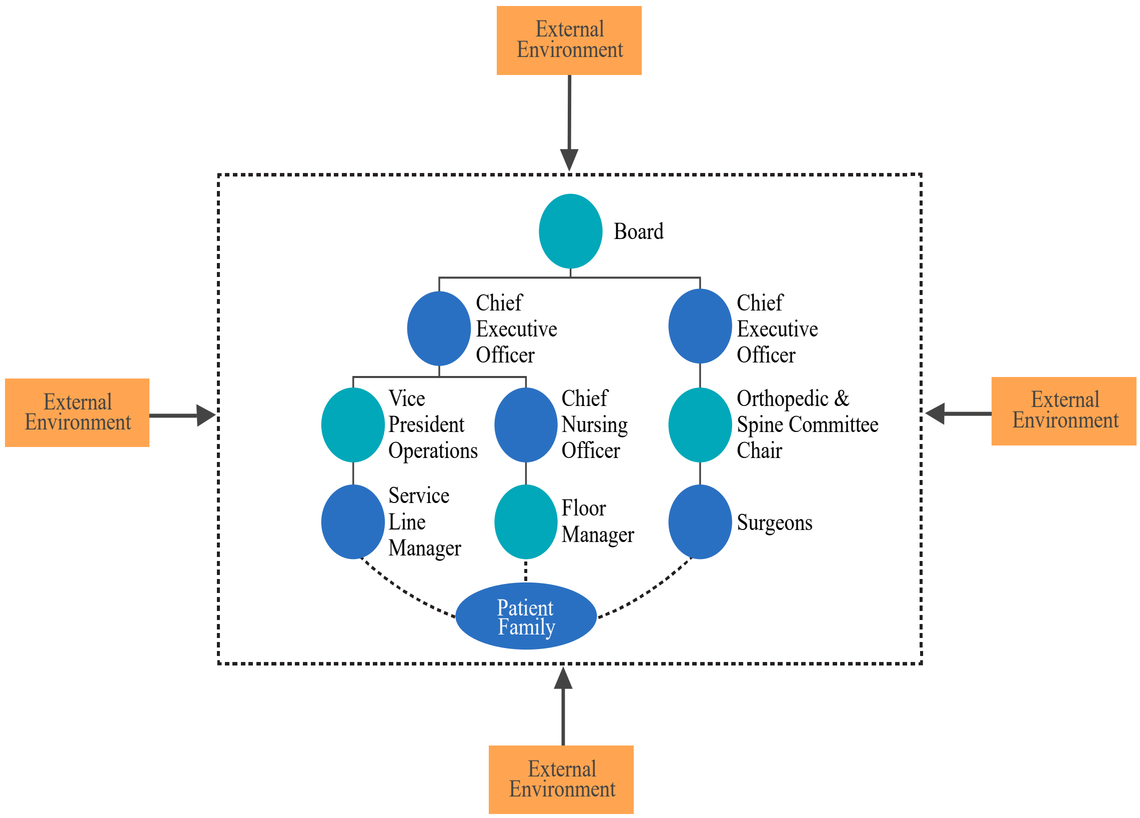
A structure-based organisation can be defined as a formal blend of relationships among individuals that come together or assist each other to deliver healthcare services by following policy, rules and procedures (Carroll & Rudolph 2006; Shukri & Ramli 2015). Though public hospitals have a management or organisational structure that encompasses relationships and responsibilities of management teams, healthcare professionals and other individuals, the structure cannot be operationalised without institutional design (Hodgson 2015). In addition, the operationalisation of the organisational structure is necessary because modern healthcare organisations have (rule-based) responsibility arrangements between medical professionals and other clinical and non-clinical individuals, commonly known as the dyad model of leadership or management (Baldwin, Dimunation & Alexander 2011; Dixit 2016; Sanford 2015). *In the context of game theory, organisational structure is critical for players' strategies because institutional design and system thinking cannot be implemented without a structure.* The structure-based organisation of healthcare service delivery can be viewed as shown in Figure 4.5

Figure 4.5: Organisation of structure-based healthcare service delivery



An alternative view of a structure-based organisation of healthcare service delivery is shown in Figure 4.6.

Figure 4.6: An alternative view of organisation of structure-based healthcare service delivery



4.3.2 A multitheoretical organisation of healthcare service delivery based on game theory, the theory of mechanism design, and the principal-agent paradigm (delegation, policy implementation and bureaucratic capacity)

Health policy formulation is the responsibility of the Commonwealth Government in Australia. State and territory governments implement the health policy in their jurisdictions (please see chapter 3 – figure 3.4). While public hospitals are jointly funded by the federal and state governments, health policy is determined at the federal level and health policy implementation is left with the state or territory governments. State or territory governments are responsible for the oversight and performance of public hospitals. In the state of Victoria, the Department of Health and Human Services has four ministers: (a) Minister for Health &

Ambulance Services; (b) Minister for Mental Health, Housing, Disability and Ageing; (c) Minister for Youth Affairs, Families and Children; and, (d) Minister for Sport (State of Victoria 2016a). Thus, the government's role presumably is an integral part of the organisation of healthcare service delivery by public hospitals.

In a game theoretical sense, if healthcare delivery by public hospitals is a game, the key players can be identified as follows: first, since this research study's focus is public hospitals, the Minister of Health and Ambulance Services of Victoria is the person responsible for the implementation of health policy and the oversight of public hospitals. He or she delegates responsibilities to the bureaucrats. Second, due to the government funding of public hospitals, taxpayers too are key players because they and their loved ones are served as patients. Third, public hospitals themselves are key players in the delivery of healthcare to patients. Last, within each public hospital, physicians and nurses play a key role in the delivery of healthcare. In this study, the focus of game theory is on three players: Minister of Health and Ambulance Services (the Minister), the bureaucrats at the Department of Health Services and public hospitals. The game theoretic model specifically focuses on public hospitals as players.

The delivery of healthcare services can be defined as a game in which all public hospitals are players. Players are rational, have information regarding other players' strategies and can improve outcomes by making unilateral moves (Başar 2015; Brandenburger 2007). In terms of the theory of mechanism design, there is a game; a main player (the principal – the Minister) who seeks to implement health policy; many players or agents (each public hospital in the state) that engage in healthcare service delivery i.e., health policy implementation specific to public hospitals. This means the principal may have to take action to induce the agents to implement the health policy as desired by him (Campbell 2006; Cihák 2008; Stiglitz 2000). In the context of the principal-agent paradigm, there are three aspects of public policy: public policy implementation error (PiE); public policy implementation efficiency (PiEf) and bureaucratic capacity (BC). While the concepts of policy implementation error and bureaucratic capacity were introduced by (Huber & McCarty 2004, 2006; Huber & Shipan 2011), the concept of public policy implementation efficiency is introduced in this research study for the first time. Both policy implementation error and bureaucratic capacity are game theoretic concepts (McCarty & Meirowitz 2007). The current state of public policy (PiE or PiEf) is known as public policy status (PiS).

4.3.3 Game theoretic issues relevant to this study

After having identified the context or environment (chapter 3) and the players, it is necessary to consider the game theoretic issues relevant to this study. There are three issues that need to be taken into consideration: (a) asymmetry of information; (b) regulation and (c) signalling.

Asymmetry of information

A situation of asymmetric information arises when one party possesses more information than another, which can influence the execution, outcome or payoff if the two parties choose to interact or enter into a contractual relationship (Bonanno 2011; Samuelson & Marks 2008). When two parties (a principal and agent or a buyer and a seller) do not have the complete information needed for decision-making, the problem of asymmetric information arises. When dealing with a situation of information asymmetry, the party with less or no information would need to infer things from the actions of the better-informed party. Such a situation may result in a market failure and *Pareto inefficiencies*. Pareto efficiency, or Pareto optimality represents a situation where the allocation of resources has been done in such a way that any changes to it would make it impossible to leave any one party better off without making at least one other party worse off (Bonanno 2011). It equally applies to public managers and elected officials. If outsiders have less information, they may be reluctant to replace the elected officials (or bureaucrats) fearing the costs of transition (Stiglitz 2002).

The healthcare sector is swamped with information; various groups of patients - under managed and non-managed care - are affected differently by information asymmetry. For example, patients covered by managed care plans have less trust in their primary care physicians (Dwyer, Liu & Rizzo 2012). Also, as a result of patients becoming more familiar with healthcare information, the physicians' and patients' knowledge are no longer substitutes; instead the two information sets complement each other (Smith 2005). The asymmetry of information complicates the task of measuring and assessing healthcare quality, as healthcare providers and patients view quality differently, hence the patients' views should be taken into consideration while evaluating quality (Carruthers & Jeacocke 2000).

In the public healthcare sector (e.g., pubic hospitals in the state of Victoria), information asymmetry can occur in the following ways: (a) between the public (patients and families) and healthcare professionals (doctors, nurses and other clinicians); (b) between the public (patients and families) and healthcare administrators and/or systems (hospital administration, bureaucrats and politicians); and (c) between the healthcare professionals (doctors, nurses and other clinicians) and healthcare administrators and/or systems (Preker & Harding 2000).

Regulation

Before the 1980s, the economics of regulation was a compendium of literature based on arbitrary assumptions and regulatory processes. Sappington (1982) examined the optimal strategy of a regulator who is focused on maximising consumer surplus while the technological capabilities of the entity being regulated are unknown. Without having any consideration for quality, the asymmetry of information and incentives for cost minimisation, many nations constrained the rate of return on capital to attract investment in their utility sectors and to curb the power of monopolies (Laffont 1994). Economists' thinking diverged when Loeb and Magat (1979) proposed a regulatory system for utility companies, under which such companies were to be subsidised on a per unit basis with an amount that was equal to the consumers' surplus.

Similarly, Weitzman (1978) suggested that regulations based on price incentives and quantity targets would be optimal. Building further on the work of Weitzman (1978) and Loeb and Magat (1979), assuming that monopolistic firms' costs are unknown, Baron and Myerson (1982) used the maximization of linear social welfare as the regulator's objective, consumers' surplus and firms' profit as the functions. Therefore, an optimal social welfare policy could be described as one where social welfare is maximised, subject to the constraints that firms do not incur losses and there is no incentive for the firms to manipulate the costs.

Governments in all developed nations intervene or regulate healthcare providers, including physicians, healthcare insurance companies and hospitals. Both healthcare insurance companies and governments are shifting to payment mechanisms based on quality and patient outcomes (CMS 2015b). In this changing environment, the governments' role in financing healthcare is also evolving as policymakers look for alternate ways to generate revenue for healthcare services (Stabile & Thomson 2013). Multiple layers of regulations are complex, time consuming and confusing at times for healthcare professionals (Field 2008). In the state of Victoria, the government not only makes the regulations, it also runs the public hospitals. It can be characterised as a dual role of the government as the regulator and the operator of public hospitals.

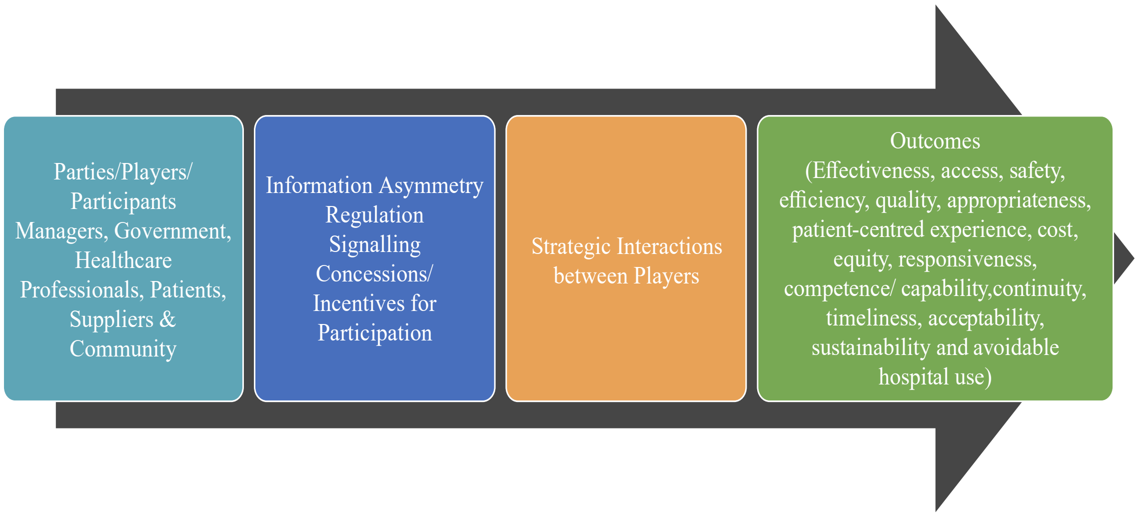
Signalling

In game theory, signalling addresses the issues related to communication or information in a multi-agent system which is often characterized by information asymmetry and agency role conflicts. As per Kirmani and Rao (2000), signalling can be used to reduce the quality or the product's information dubiety and information asymmetry. Spence (1973) coined the signalling theory by introducing the basic equilibrium signalling model, which became the foundation of sequential equilibrium. Spence showed how signalling influences job choices and employees' selection in the market and that a job applicant can use education for signalling his/her ability to an employer (Karasek & Bryant 2012).

Chen (2011) developed a two-stage signalling game to randomly match the providers and patients using healthcare report cards to show the effects of healthcare report cards in the United States. That is why Mascarenhas, Kesavan and Bernacchi (2013) recommended the use of the signalling theory to address the problem of information asymmetry in healthcare. Signalling theory has also been used to show how rigorous accreditation processes help healthcare service providers review where they stand in regard to quality and further improvement (Walker & Johnson 2009); raising breast cancer awareness in India (Fletcher-Brown, Pereira & Nyadzayo 2018); and to investigate the importance of physician training (Towler, Watson & A. Surface 2014).

While public hospitals are players in the context of game theory, healthcare services are delivered by multidisciplinary teams of healthcare professionals and other personnel. Public hospitals along with teams of professionals possess more technical or expert information than the principal (the Minister), therefore, both parties interact or enter into a contractual relationship (Bonanno 2011; Samuelson & Marks 2008). The organisation of healthcare service delivery underpinned by game theory, the theory of mechanism design and the principal-agent paradigm is presented in Figure 4.7.

Figure 4.7: Organisation of healthcare service delivery based on game theory, the theory of mechanism design and the principal-agent paradigm



4.4 Justification for choosing the problem or issue of average length of stay (ALOS) for the organisation of healthcare service delivery

A patient is usually admitted to a hospital in one the following two ways: (a) admitted directly as an inpatient - including the same day discharges both for medical and surgical procedures; (b) admitted after treatment in the emergency department. If a researcher chooses game theoretical modelling for the same day discharges and emergency room services, average length of stay would probably not be the central focus of the players' strategy. In addition, medical and surgical treatment is mostly provided in an inpatient setting.

A two-stage analysis was done before selecting average length of stay as the central focus of the game theoretical model of this study (see Table 4.1). First, the practical aspects of healthcare service delivery were analysed. Second, a mapping of the issues identified in chapter 3 was undertaken.

Table 4.1: Mapping of the theoretical underpinnings and issues or problems of public hospitals

Criteria/Issues	Institutional design	Systems approach	Structure-based approach	Game theory, the theory of mechanism design and the principal-agent paradigm
Key elements or theoretical underpinnings of healthcare service delivery	Individuals and organisations collaborate to deliver healthcare as per the rules, regulations, policies, and social norms. Incentives and disincentives are instituted for individuals and organisations to seek their cooperation to deliver effective and efficient healthcare services. Rules and environment shape the interactions among individuals and organisations.	Systems and subsystems must be in sync for the delivery of (e.g., value-based) healthcare services. Systems and subsystems are to be brought to a steady state (i.e., must work smoothly). Complex adaptive systems and subsystems adapt to changes in the environment. Systems and subsystems include different physical and human components of healthcare service delivery.	Organisational structures are created, modified, and maintained to facilitate decision-making for the delivery of healthcare services. Rules, policies, and procedures are required for the creation of organisational structures. Changes in the environment may also require changes in organisational structures.	Rational players (individuals, groups, and organisations) interact with each other to achieve their objectives (e.g., value-based healthcare services).

Expected outcomes	Delivery of healthcare services as per the rules, regulations, policies, and social norms.	Delivery of healthcare services by steady and optimised systems and subsystems (care coordination).	Delivery of healthcare services by ensuring smooth decision-making and flow of information (e.g., clinical knowledge).	Delivery of healthcare services by strategic interactions.
Chapter 3 (Sections 3.10.1, 3.10.2 and 3.10.3) Increase funding and/or redesign healthcare service delivery and/or redesign reimbursement methods and/or ensure appropriateness of care	Rules, regulations, policies, and social norms will need to be changed to achieve this goal.	Any increase in funding and/or redesign of healthcare service delivery will require smooth functioning of the systems and subsystems.	If pressure comes from the environment, organisational structures will need adjustment both to increase funding and redesign healthcare service delivery.	Different forms of games and mechanism can be designed to address this issue. ***Funding or financing is not the central theme of this study. Therefore, this issue was not chosen for game theoretical modeling.***
Chapter 3 (Section 3.10.3) A game theoretical analysis of the organisation of healthcare service delivery	Interactions among individuals and organisations are shaped by rules, regulations, policies, and social norms.	Since systems and subsystems have a human component (patients, healthcare professionals and others), they ought to be included in a game theoretical analysis of the organisation of healthcare service delivery.	Different players engaged in delivery of healthcare services are connected by an organisational structure.	Healthcare professionals, hospital administrators, bureaucrats and politicians can be characterised as players. ***Organisation of delivery of healthcare services is the analytical focus of this study.***

Chapter 3 (Section 3.10.3) Hospital bed availability, waitlists and average length of stay	Patient admissions, delivery of healthcare services and discharge from hospitals are subject to rules, regulations, policies, and social norms.	Patient admissions, delivery of healthcare services and discharge from hospitals require a smooth functioning of the systems and subsystems. Systems and subsystems are patients, healthcare professionals, and hospital administrators.	Every individual involved in healthcare service delivery is directly or indirectly tied to an organisational structure.	***Average length of stay (ALOS) is the most suitable issue for game theoretic modelling because a redesign of healthcare service delivery and an improvement in ALOS, though indirectly, would most likely result in improving hospital bed availability and wait lists.***

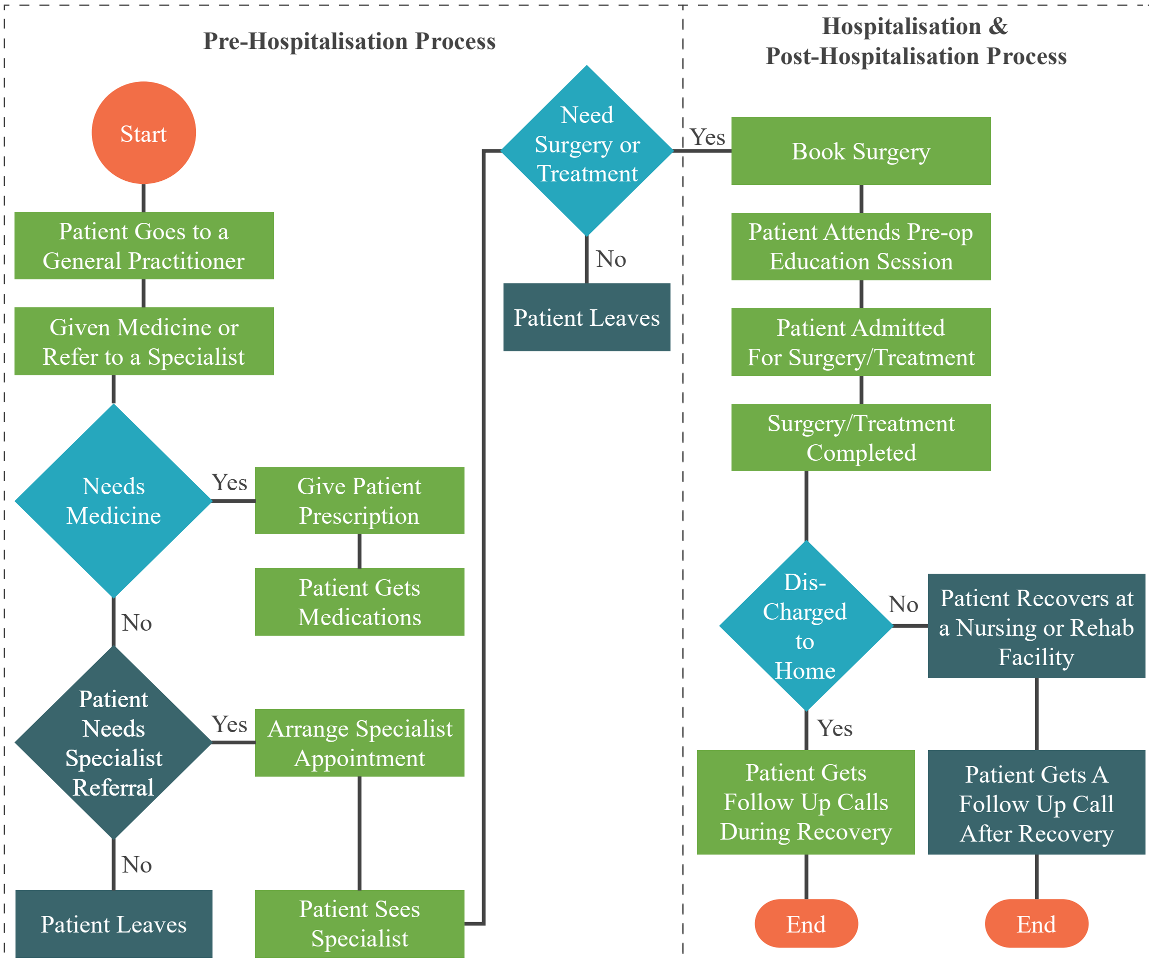
The mapping of the issues identified in chapter 3 clearly indicates that bed availability, wait lists and average length of stay are among the most serious problems facing the Australian healthcare system. Evidence suggests that Enhanced Recovery after Surgery pathways (ERASp) significantly improve perioperative care and functional outcomes, thereby reducing the average length of stay, complications and overall healthcare costs (Agarwala, Butani, D'Mello, Saksena & Menon 2020). The average length of stay in hospitals is seen as an indicator of efficiency and effectiveness because shorter hospital stays not only reduce healthcare costs, but also improve care coordination (e.g., appropriateness of care) and health outcomes (OECD 2019). It also helps reduce the chances of re-admissions because re-admissions are an indicator of the poor quality of healthcare services and the inefficient use of hospitals beds that could otherwise be used to reduce wait lists.

The average length of hospital stay of a patient depends on the coordinated efforts of healthcare professionals and other hospital personnel who engage in the delivery of healthcare services from the time of admission to discharge. The delivery of healthcare services is shaped by rules, regulations, social norms etc. as per the institutional design. As per system thinking, a set of different subsystems (e.g., healthcare professionals; non-healthcare professionals; other employees; technology; patients; families, suppliers etc.) are optimised for delivery of healthcare services. The responsibility, accountability and authority relationships are in place for the structure-based organisation of healthcare service delivery. Therefore, the issue of average length of stay can be used for game theoretic modelling by choosing public hospitals as the players and the Minister as a social planner within the scope of the theory of mechanism design.

Agents have divergent interests in a healthcare system. Policymakers' interests are determined by perceived priorities, regulatory control over the (delivery of) healthcare services and financial constraints. Public hospitals' resource constraints have different dimensions, for example: (a) public hospitals are compartmentalised; (b) their workforce is unstable; (c) they face staff shortages; (d) there is a high level of bureaucracy; and (e) their performance is based on throughput (Sturmberg 2018). It is important to understand what is involved when a medical or surgical procedure is performed in a hospital.

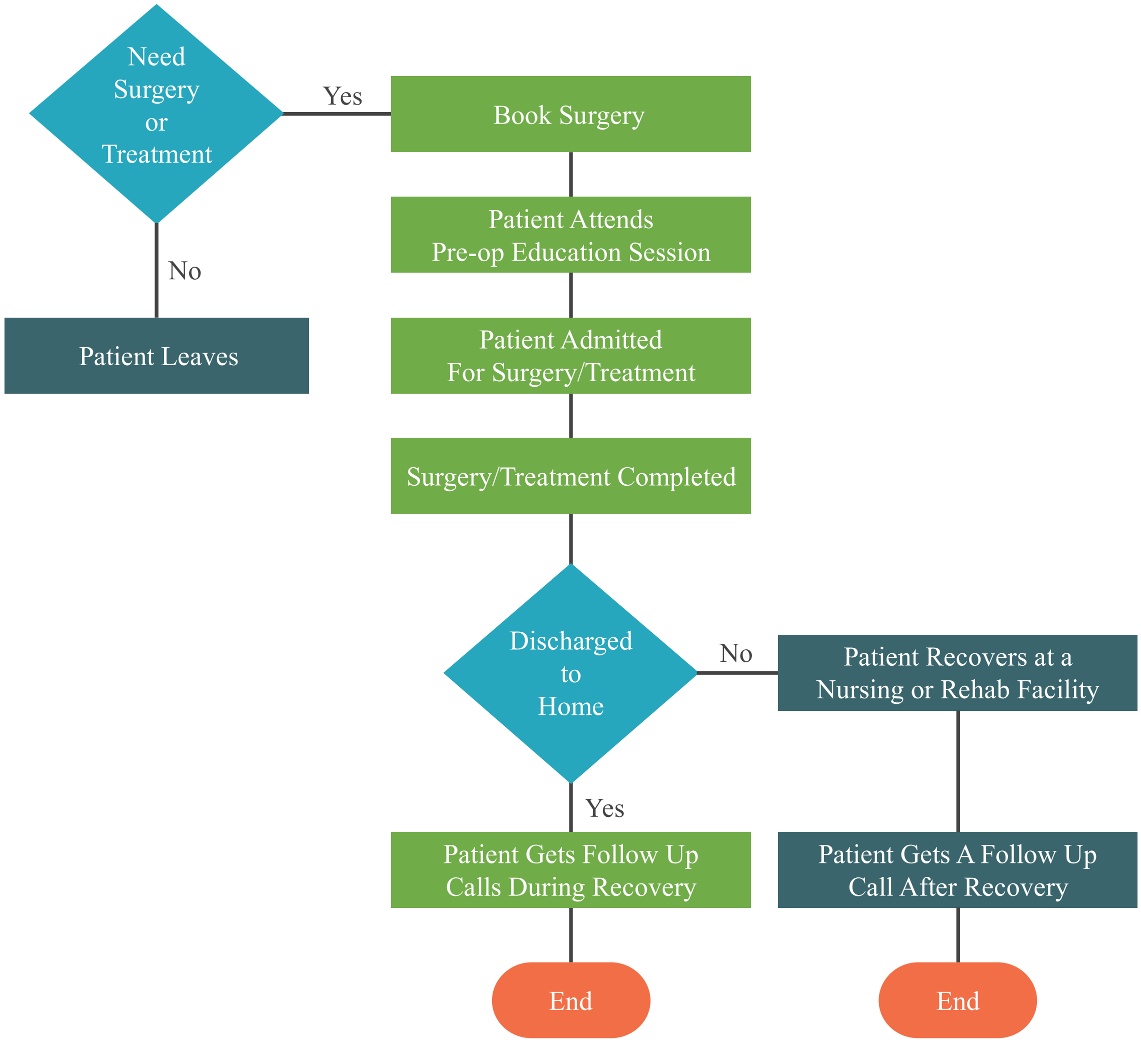
A patient is referred to a hospital either by a general practitioner or a specialist for a medical or surgical treatment. A patient encounters the administrative staff at the hospital before the care is delivered by a multidisciplinary team. After the treatment is complete, the patient is discharged. The following individuals are typically involved in during a patient's stay at the hospital: (a) administrative staff; (b) nurses; (c) physicians; (d) surgeons: and (e) allied health professionals. The medical or surgical treatment is subject to policy, rules, regulations, and contracts (explicit and implicit). Each person is bound by the rules, regulations, and professional code of practice. The treatment and the professionals involved can either be defined as a system or subsystem. The hospital and each one of its departments can also be defined as a system or subsystem. These systems and subsystems are influenced by the external environment (e.g., the state of the population's health, regulations etc). Every individual involved in the delivery of healthcare is also tied into a structure that sets the authority and responsibility (relationships) subject to policy and procedures. The process of the organisation of healthcare service delivery can be divided into two categories: (a) pre-hospitalisation; and (b) hospitalisation and post- hospitalisation, as shown in Figure 4.8.

Figure 4.8: The whole cycle of healthcare service delivery from pre-hospitalisation to post-hospitalisation



The focus of this study is the organisation or organising of healthcare service delivery during and after hospitalisation until a patient has recovered. It is the process of hospitalisation and post-hospitalisation that directly links to approaches to the organisation of healthcare service delivery and a game theoretic view of the organisation or organising of healthcare service delivery. For the sake of clarity, this part of healthcare delivery is shown in Figure 4.9.

Figure 4.9: Organisation or organising of healthcare service delivery during hospitalisation and post-hospitalisation



4.5 Research methodology and data sources

As per Kothari (2004, p. 8), "Research methodology is a way to systematically solve the research problem. It may be understood as a science of studying how research is done scientifically." Research methodology depends on the objectives, research question(s), subject and context of a research study. The subject, objectives and context of this research study - as it seeks to find the solution to a critical practical problem (Mishra & Alok 2017) – revolve around the organisation or organising of healthcare service delivery by public hospitals. Game theoretic modelling is not a qualitative or quantitative or mixed research method. It is generally considered a paradigm. While game theoretic modelling is used for decision-making, games are strategic interactions between players (Salkind 2010). This study uses some components of qualitative methods as it builds the conceptual model from the underpinnings of the three (theoretical) approaches to the organisation of healthcare service delivery. These approaches along with the underpinnings of game theory, the theory of mechanism design and the principal-agent paradigm form a logical foundation of the game theoretic model. This research study uses MATLAB for game theoretical modelling.

Public hospital data is available on the *MyHospitals* portal of the Australian Institute of Health and Welfare (AIHW 2018). However, the limited datasets that are available on the portal have been released after years of delay. An endeavour was made to obtain the data from the Department of Health, Victoria. The government was reluctant to release the public hospital performance data, as requested. A Freedom of Information (FOI) request was made. However, the government did not change its stance and the limited data it released could not be used for this research study as it was inadequate for game theoretic modelling. It was then decided to extract the data from the *MyHospitals* portal and make changes to it for game theoretic modelling. It was also decided to leave the year information out because the data has been changed to fit game theoretic modelling. Instead of identifying the hospitals, the players have been labelled as hospital 1, 2, 3…... A review by the Ethics Committee was not required because no identifiable patient data has been used in this research study. No other ethical issues or risks were identified.

4.6 Policy implementation and bureaucratic capacity

The Minister is the social planner and public hospitals are the players. In a governmental setting, the social planner or principal does not have the same flexibility to design mechanisms for the agents as in the case of private enterprises, which is defined as a constrained mechanism design.

A constrained mechanism design, as per the Epstein and O'Halloran (1999) model can be expressed as follows:

$$\max_{p} \quad \{-(a - p + \varepsilon)^2\}\ subject\ to\ p \in P \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(4.6.1)}$$

where p represents a policy choice made by the legislature; a is the ideal point of policy choice (of a social planner or principal); and ε represents the error or the difference between the policy choice and actual policy implemented by the bureaucrats.

With regard to bureaucratic capacity, one of the agent's maximisation models by Huber and McCarty (2004) suggests:

$$p^* = \{a + \varepsilon\}\ if\ \bar{p} - \varepsilon \leq a - \Omega \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(4.6.2)}$$

In the above, p^* represents the policy as implemented; a is the point where the social planner would like the policy to be; ε is policy implementation error; and Ω is the measurement of bureaucratic capacity.

The Epstein and O'Halloran (1994, 1999) models of delegation to bureaucrats assume that a government agency (subject to the oversight by the legislative branch) can fully and perfectly implement the policy without error (in advanced countries). If the policy is not fully implemented, bureaucratic capacity may be a reason for an implementation error. Therefore, following the guidelines from the Minister, the bureaucrats are expected to set the health policy at p. Thus,

p - p^* = policy implementation error (PiE)……………………………….……………….(4.6.3)

If the outcomes set out by p are better (or higher in quantitative terms) than the actual outcomes of p^* i.e., the policy targets have not been met .

p - p^* = policy implementation efficiency (PiEf)………………………………….….(4.6.4)

If the outcomes set out by p are worse (or lower in quantitative terms) than the actual outcomes of p^* i.e., the policy targets have been met and the actual outcomes are better than the target policy outcomes.

In this research study, it is assumed that a perfect bureaucratic capacity is represented by 0, and PiS (policy implementation status) can be ascertained by comparing the actual policy outcomes to the target policy targets outcomes (Dixit, Sambasivan & Islam 2019).

Thus, if PiS < 0, then PiS = PiE ……………………………………………………………… (4.6.5)

If PiS > 0, then PiS = PiEf. ……………………………………………………………… (4.6.6)

A social planner's main goal should be to minimize the policy implementation error (PiE) by seeking to improve the actual policy outcomes (Dixit & Sambasivan 2018). When the actual policy outcomes are better than the policy target outcomes, the Minister may choose to divert resources from the areas of PiEfs to PiEs. Alternatively, the Minister may focus solely on either PiEs or PiEfs (Dixit, Sambasivan & Islam 2019).

A public hospital's policy outcomes (p*) for the selected measure (average length of stay or ALOS) could be ascertained at three levels - at the hospital level, at the peer level and at the system level. The average of ALOS of all public hospitals in the same peer group is assumed to be the actual policy target (p). Thus, the simple mathematical notations and corresponding examples of PiS computation are presented below:

Policy implementation status at the hospital-level (ALOS)

$$PiSHos_{ai1} = (pHos_{ai1}) - (pHos^{*}_{ai1}) \quad \ldots \quad (4.6.7)$$

$$a = timeliness, i = ALOS, \; j = 1, \ldots, n.$$

where *PiS Hos* is the policy implementation status of a hospital *Hos*, *a* being the outcome indicator (e.g., timeliness), *i* being the sub-category of an outcome indicator (e.g., ALOS, ED stay, waiting time etc.), *1-n* being the different segments of a sub-category of an outcomes indictor (e.g., appendix removal, knee replacement, hip replacement etc.). For example, *PiS* for average length of stay *(a=timeliness; i=ALOS)* of Austin Hospital, Heidelberg Campus (*AHHC*) for the condition *total hip replacement* (ai_1*=THR*) can be expressed as follows: -

$$PiSAHHC_{aALOSTHR} = (pAHHC_{aALOSTHR}) - (pAHHC^{*}_{aALOSTHR}) \quad \ldots \quad (4.6.8)$$

Similarly, the overall PiS status of ALOS for a public hospital for all conditions, N being the number of conditions, can be expressed as follows:

$$PiSHos_{ai1-n} = \sum_{j=1}^{j=n} \frac{PiSHos_{aij}}{N} = \frac{[(PiSHos_{ai1})+(PiSHos_{ai2})+(PiSHos_{ai3})+\cdots+(PiSHos_{ain})]}{N} \quad \ldots\ldots(4.6.9)$$

Policy implementation status at the peer level (ALOS)

$$PiSPg_{ai1} = \sum_{j=1}^{j=n} \frac{PiSHospj_{ai1}}{N_h} = \frac{[(PiSHosp1_{ai1})+(PiSHosp2_{ai1})+(PiSHosp3_{ai1})+\cdots+(PiSHospn_{ai1})]}{N_h} \quad \ldots\ldots(4.6.10)$$

where $PiSPg$ is policy implementation status, *pg* hospital peer group, *a* being the outcome indicator (e.g., timeliness, cost etc.), *i* being the sub-category of an outcome indicator (e.g., ALOS, ED stay, waiting time etc.), *1-n* being the different segments of a sub-category of an outcomes indictor (e.g., appendix removal, knee replacement, hip replacement etc.). For example, if the *PiS* for the peer group *major hospitals (pg=MH)* for average length of stay *(a=timeliness; i=ALOS)* for the condition *total hip replacement (i1=THR),* N_h being the number of hospitals in the peer group, it can be expressed as follows: -

$$PiSMH_{aALOSTHR} = \sum_{j=1}^{j=n} \frac{PiSHospj_{aALOSTHR}}{N_h} =$$

$$\frac{[(PiSHosp1_{aALOSTHR})+(PiSHosp2_{aALOSTHR})+(PiSHosp3_{aALOSTHR})+\cdots+(PiSHospn_{aALOSTHR})]}{N_h} \quad \ldots\ldots(4.6.11)$$

Similarly, the PiS of a peer group for all conditions, where N_h is the number of hospitals in the peer group, can be expressed as follows:

$$PiSPg_{ai1-n} = \sum_{j=1}^{j=n} \frac{PiSHospj_{ai1-n}}{N_h} =$$

$$\frac{[(PiSHosp1_{ai1-n})+(PiSHosp2_{ai1-n})+(PiSHosp\ 3_{ai1-n})+\cdots(PiSHospn_{ai1-n})]}{N_h} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (4.6.12)$$

Policy implementation status at the system level (ALOS)

Victoria's health system has a subsystem, comprising many public hospitals, for which the PiS is calculated in this study for average length of stay (ALOS) for total hip replacement. Thus, the PiS of the public hospital subsystem ($PiSHospSubsys$) can be expressed as:

$$PiSHospSubsys_{ai1} = \sum_{j=1}^{n} \frac{PiSPgj_{ai1}}{N_{pg}} =$$

$$\frac{[(PiSPg1_{ai1})+(PiSPg2_{ai1})+(PiSPg3_{ai1})+\cdots+(PiSPgn_{ai1})]}{N_{pg}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (4.6.13)$$

where *pg* is hospital peer group, *a* is the outcome indicator (e.g., timeliness, cost etc.), *i* is the sub-category of an outcome indicator (e.g., ALOS, ED stay, waiting time etc.), *1-n* is the different segments of a sub-category of an outcomes indictor (e.g., appendix removal, knee replacement, hip replacement etc.). For example, the *PiS* for average length of stay *(a=timeliness; i=ALOS)* of the entire public hospital subsystem for the condition *total hip replacement* *(i_1=THR),* where N_{pg} is the number of peer groups in the subsystem, can be expressed as follows: -

$$PiSHospSubsys_{aALOSTHR} = \sum_{j=1}^{j=n} \frac{PiSPgj_{aALOSTHR}}{N_{pg}} =$$

$$\frac{[(PiSPg1_{aALOSTHR})+(PiSPg2_{aALOSTHR})+(PiSPg3_{aALOSTHR})+\cdots+(PiSPgn_{aALOSTHR})]}{N_{pg}} \text{………...….. (4.6.14)}$$

Similarly, the PiS of the public hospital subsystem for all conditions, where N_{pg} is the number of peer groups in the subsystem, can be expressed as follows:

$$PiSHospSubsys_{ai1-n} = \sum_{j=1}^{n} \frac{PiSPgj_{ai1-n}}{N_{pg}} =$$

$$\frac{[(PiSPg1_{ai1-n})+(PiSPg2_{ai1-n})+(PiSPg\ 3_{ai1-n})+\cdots+(PiSPgn_{ai1-n})]}{N_{pg}} \text{……………………….………(4.6.15)}$$

Therefore, all public hospitals in the Victorian public hospital system can be defined as subsystems. Any improvements in quality or other performance indicators of the public hospital system will require similar improvements in each public hospital's performance. Therefore, the policy implementation status (PiS) of the Victorian public hospital system could be tabulated as shown in Table 4.2.

Table 4.2: Policy Implementation Status (PiS) of Public Hospitals

Hospital/Outcome Indicator, sub-category & health condition	$ai1$	$ai2$	$ai3$	$ai4$	$ai5$	……	……..	ain
$Hosp1$	$PiSHos1_{ai1}$	$PiSHos1_{ai2}$	$PiSHos1_{ai3}$	$PiSHos1_{ai4}$	$PiSHos1_{ai5}$	……	……..	$PiSHos1_{ai1}$
$Hosp2$	$PiSHos2_{ai1}$	$PiSHos2_{ai2}$	$PiSHos2_{ai3}$	$PiSHos2_{ai4}$	$PiSHos2_{ai5}$	……	……..	$PiSHos2_{ain}$
$Hosp3$	$PiSHos3_{ai1}$	$PiSHos3_{ai2}$	$PiSHos3_{ai3}$	$PiSHos3_{ai4}$	$PiSHos3_{ai5}$	……	……..	$PiSHos3_{ain}$
$Hosp4$	$PiSHos4_{ai1}$	$PiSHos4_{ai2}$	$PiSHos4_{ai3}$	$PiSHos4_{ai4}$	$PiSHos4_{ai5}$	……	……..	$PiSHos4_{ain}$
$Hosp5$	$PiSHos5_{ai1}$	$PiSHos5_{ai2}$	$PiSHos5_{ai3}$	$PiSHos5_{ai4}$	$PiSHos5_{ai5}$	……	……..	$PiSHos5_{ain}$
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
$Hospn$	$PiSHosn_{ai1}$	$PiSHosn_{ai2}$	$PiSHosn_{ai3}$	$PiSHosn_{ai4}$	$PiSHosn_{ai5}$	……	……	$PiSHosn_{ain}$

The total dollar value of PiS (PiS$) for each hospital in the health system and the system as a whole can be expressed as follows:

PiS$ = (PiS*NoP*PdR) – (PiS*NoP*PdC) ………………………..……………………..…(4.6.16)

where NoP is the number of patients, PdR is the per day revenue and PdC is the per day cost of hospital stay. These simple arithmetic calculations can be undertaken for each health condition, each hospital, each peer group, and the entire public hospital system. The total dollar value of PiS (PiS$) could be tabulated as shown in Table 4.3. The indicators used in the model and their description are shown in Table 4.4.

Table 4.3: Total dollar value of the policy implementation status (PiS)

Hospital/Outcome Indicator, sub-category & health condition	$ai1$	$ai2$	$ai3$	$ai4$	$ai5$	……	……..	ain
$Hosp1$	$PiS\$Hos1_{ai1}$	$PiS\$Hos1_{ai2}$	$PiS\$Hos1_{ai3}$	$PiS\$Hos1_{ai4}$	$PiS\$Hos1_{ai5}$	……	……..	$PiS\$Hos1_{ai1}$
$Hosp2$	$PiS\$Hos2_{ai1}$	$PiS\$Hos2_{ai2}$	$PiS\$Hos2_{ai3}$	$PiS\$Hos2_{ai4}$	$PiS\$Hos2_{ai5}$	……	……..	$PiS\$Hos2_{ain}$
$Hosp3$	$PiS\$Hos3_{ai1}$	$PiS\$Hos3_{ai2}$	$PiS\$Hos3_{ai3}$	$PiS\$Hos3_{ai4}$	$PiS\$Hos3_{ai5}$	……	……..	$PiS\$Hos3_{ain}$
$Hosp4$	$PiS\$Hos4_{ai1}$	$PiS\$Hos4_{ai2}$	$PiS\$Hos4_{ai3}$	$PiS\$Hos4_{ai4}$	$PiS\$Hos4_{ai5}$	……	……..	$PiS\$Hos4_{ain}$
$Hosp5$	$PiS\$Hos5_{ai1}$	$PiS\$Hos5_{ai2}$	$PiS\$Hos5_{ai3}$	$PiS\$Hos5_{ai4}$	$PiS\$Hos5_{ai5}$	……	……..	$PiS\$Hos5_{ain}$
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
$Hospn$	$PiS\$Hosn_{ai1}$	$PiS\$Hosn_{ai2}$	$PiS\$Hosn_{ai3}$	$PiS\$Hosn_{ai4}$	$PiS\$Hosn_{ai5}$	……	……	$PiS\$Hosn_{ain}$

Table 4.4: Indicators used in the game theoretic model and their description

Indicator	Description
p	Policy target
$p*$	Policy outcome
a	Social planner's desired policy outcome
ε	Policy implementation error
Ω	Measurement of bureaucratic capacity
p - p^*	Policy implementation error (PiE), if the outcomes set out by p are better than the actual outcomes of p^* i.e., the policy targets have not been met
p - p^*	Policy implementation efficiency (PiEf), if the outcomes set out by p are worse than the actual outcomes of p^* i.e., the policy targets have been met and the actual outcomes are better than the target policy outcomes
PiS	Policy implementation status
PiSHos	Policy implementation status of a hospital
ai	Outcome indicator a for surgical or medical condition *i*
$PiSPg$	Policy implementation for hospital peer group
$PiSHospSubsys$	Policy implementation of a subsystem comprising of all peer groups
$ai1$	Appendix removal
$ai2$	Caesarean delivery
$ai3$	Cellulitis
$ai4$	Chronic obstructive pulmonary disease (with complications)
$ai5$	Chronic obstructive pulmonary disease (without complications)
$ai6$	Gallbladder removal
$ai7$	Gynaecological reconstructive procedures
$ai8$	Heart failure (with complications)
$ai9$	Heart failure (without complications)
$ai10$	Hip replacement
$ai11$	Hysterectomy
$ai12$	Kidney and urinary tract infections (with complications)
$ai13$	Kidney and urinary tract infections (without complications)
$ai14$	Knee replacement
$ai15$	Prostate removal
$ai16$	Vaginal delivery
PiS$	Dollar value of the policy implementation status
NoP	Number of patients
PdC	Per day cost of stay in hospital
PdR	Per day revenue for stay in hospital

4.7 The model

A cooperative game is possible if a binding contract exists among the players even though it may not be apparent or formally in existence before a game begins (Chalkiadakis, Elkind & Wooldridge 2011). As per Shubik and Powers (2016), while cooperative games are normative, noncooperative games are experimental. McCarty and Meirowitz (2007) described the game theoretic relationship between a social planner (the Minister of Health) and the bureaucrats or between a principal and his agents. While the Minister, a politician, the bureaucrats in the Department of Health as well the professionals who are responsible for the governance and management of each public hospital are expert bureaucrats. The Minister must consider that:

"Bureaucrats are likely to be predisposed toward certain positions on the policies they implement because they are usually experts in their field, their work is affected by the policies they are asked to implement, and they are bound by norms that influence their policy positions (Andersen & Jakobsen 2017).*"*

Currently, as public hospitals are reimbursed using an activity-based mechanism, they are most likely not motivated to reduce the PiE because more activity results in more funding or reimbursement from the government. In addition, even if the hospitals players are rational, they may not be too keen to change the status quo because a change would require: (a) more work, (b) efficiency, and (c) reallocation of resources. Public hospitals (players or agents) have no reason to cooperate with the Minister or government because even if they seek to reduce the policy implementation error, they will not be given any financial or intrinsic or reputational incentives. There has to be some sort of reward or penalty or regulation that reflects costs and benefits of cooperation among the players (public hospitals).

Before selecting and evaluating the suitability of a game to improve the PiS of public hospitals, a few important issues must be considered. First, the human and financial resources needed for the delivery of healthcare services are constrained. Second, public hospitals have no choice but to improve if public funding of healthcare is to be sustained. Third, cooperation among public hospitals is needed for improvement of the PiS because healthcare services could be considered a common pool of resources. Last, as mentioned in the previous paragraph, public hospitals could be defined as selfish and players could be called egoist if they are interested in keeping the status quo. It is possible that public hospitals (players in the context of game theory), may not cooperate with one another at first, however, cooperation may evolve over a period of time.

Thus, the issues discussed in the previous two paragraphs could be characterized as a social dilemma game (Rezaei, Kirley & Pfau 2009) or a prisoner's dilemma game. A prisoner's dilemma game becomes more interesting when the players play this game iteratively (called the Iterated Prisoner's Dilemma or IPD) and the payoffs are accumulated over each iteration (Mittal & Deb 2009). The interaction must extend for an unknown number of moves for cooperation to evolve and possibly for an equilibrium (Axelrod 1988).

4.7.1 The Minister's (social planner) proposal

Since the bureaucratic capacity in developed countries is expected to be perfect (PiS=0 or at least PiE=0), the social planner would want the players to minimize the PiE or reduce it to 0. In addition, due to the problem of rising healthcare costs and the growing demand for elective surgeries (Dixit 2016), healthcare providers and the reimbursing institutions are looking at ways to reduce costs while maintaining or improving quality and patient outcomes. A bundled payment or episodic payment mechanism is one of the ways to reduce costs by linking payments to a target price. Bundled payments can be described as a mix of fee-for-service and capitation payments under which doctors, hospitals and other healthcare providers share a single fee amount paid for all aspects of a particular procedure (AMA 2012). In other words, cooperation among all healthcare services professionals (and providers) is required.

It is proposed that the Minister introduces a comprehensive plan to reform the current payment mechanism in a bid to reduce policy implementation error. A bundled payment mechanism similar to the one that has already been implemented by the Centers for Medicare & Medicaid Services (CMS) in the United States (CMS 2015b) may be ideal. CMS covers the health care benefits – Medicare, Medicaid and State Insurance for Children - of about 90 million Americans (CMS 2015a). This is why the bundled payment mechanism will be relatively easier to implement in a significantly smaller Australian health system. The proposed bundled payment mechanism will hold hospitals financially accountable and give them incentives for coordination among hospitals, surgeons, and post-surgery care providers outside the hospitals. The Minister may penalize hospitals that do not meet the cost and quality benchmarks.

The bundled payment program will require public hospitals to efficiently deliver a high quality of care. The dimensions of the quality would be: (a) pre-admission education for the patients who have not been admitted through the Emergency Department (ED; (b) readmissions for related complications within 90 days of discharge from hospital; and (c) patient satisfaction surveys collected from the patients who were admitted for a medical treatment or surgical procedure. As a result of the proposed bundled payment, healthcare delivery will have to be coordinated between different healthcare providers. Although participation in the mechanism or programme being proposed by the Minister will not be mandatory, every public hospital will be required to undertake pre-defined business improvement initiatives to reduce the PiE whether or not it participates in the bundled payment programme. If a hospital participates in the bundled payment program and cooperates, the business improvement costs will be reimbursed by the Minister. Cooperating players (hospitals) will also receive incentives. The Minister's bundled payment proposal will put the public hospital in a dilemma as to whether to participate in the programme or not. In other words, a situation of social or prisoner's dilemma will arise for the public hospitals as discussed in the rest of this chapter.

4.7.2 Public hospitals' social or prisoner's dilemma

There are 79 public hospitals in Victoria that offer a variety of healthcare services (medical and surgical treatment and procedures). The Minister's proposal that has been discussed in the previous section requires hospitals to meet the following four requirements: (a) implement a business improvement program; (b) provide pre-admission education to the patients; (c) take steps to reduce and/or eliminate the need for a readmission for related complications within 90 days: and (d) collect patient satisfaction surveys from the patients to determine the patient satisfaction scores.

As indicated in the previous section, requirement (a) is mandatory for all public hospitals whether or not they participate, cooperate or defect in a prisoner's dilemma game. It is expected that requirements (b), (c) and (d) will result in the successful implementation of the bundled program by a public hospital. Thus, it would be regarded as cooperation (C), not doing so will amount to defection (D). It is to be noted that the prisoner's dilemma game designed here is between public hospitals, i.e., there are 79 players.

The Minister (social planner) has designed a mechanism that he expects the players to implement. While a successful implementation would be rewarded (R), there would be penalties (P) for failure. In order to keep the game simple, it is assumed that business improvement costs will be the penalty because defection would prohibit the hospitals from seeking reimbursement for business improvement costs (C). Business improvement costs is a negative number. While the business improvement costs are different for each condition for each hospital, it is assumed that the total business improvement cost for all health conditions are the same for all players. The payoffs are ordered as follows:

$B = (R-C) > 0$. Note that $C>0$………………………………………...……………. (4.7.1)

where B is benefit, R is reward and C is cost.

Keeping in mind the US Medicare bundled payment program, in which hospitals are rewarded and penalised according to their performance, the Minister sets a point system under which cooperation would yield 100 points, while defection would result in 0 points per round. Public hospitals in Victoria have two choices, either cooperate or defect. In addition, if all hospitals cooperate, all hospitals are given 100 points each. If all other hospitals cooperate, but one hospital defects, that hospital gets 200 points, the others get 0 points. If all other hospitals cooperate, but two hospitals defect, both defectors will get 150 points each, the remaining hospitals get 0 points. If all other hospitals cooperate, but three or more hospitals defect, all hospitals will get 0 points. The matrix of this prisoner's dilemma game is shown in Table 4.5.

Table 4.5: Prisoner's dilemma matrix (C=Cooperation and D=Defection)

Strategy	All choose C	More than *n* others choose C (78C; 1D)	n others choose C (77C; 2D)	Fewer than n others choose C (76 or Less C)
C	R+C	0	0	0
D	Not Applicable	2(R)+C	1.5(R)+C	0

It is to be noted that the members who are rewarded (R) are also entitled to reimbursement of the business improvement costs (C). The computations for reimbursement of the business improvement costs are done after a game has concluded. The reimbursement of business improvement costs for each player will depend on its cumulative scores in relation to other players. The algorithm for the prisoner's dilemma game for the calculation of points as described in this section is shown in Figure 4.7

Figure 4.10: Algorithm for a point system-based iterated prisoner's dilemma game

```
For Loop from Round No. = 1 to MAX_ROUNDS

    Select 2 players out of 79 players (Players are named as 'M' and 'N')

    Check Probability of Interaction (ProbInt) between them using the variable ProbInt

    If ProbInt < Rand(), Select New Players pair
    If ProbInt >= Rand(),

    M = rand()
    N = rand()

    If(M==1 and N == 1),Then Score M = +1and Score N = +1
    If(M==0 and N == 0),Then Score M = -1and Score N = -1
    If(M==0 and N == 1),Then Score M = +3and Score N = -3
    If(M==1 and N == 0),Then Score M = -3and Score N = +3

    If (M==1 and N==1),Then Bring the ProbInt More closer
    If (M==0 and N==0),Then Take the ProbInt More further
    If (M==0 and N==1),No Change in ProbInt
    If (M==1 and N==0),No Change in ProbInt

Plot Players Score;

For Loop Contd. Till MAX_ROUNDS

Final Players Score.
```

4.7.3 Evolving cooperation in the n-person prisoner's dilemma

Social dilemma games like the prisoner's dilemma are able to provide insightful properties of interactions in multi-agent systems and have a wide variety of applications in many fields such as biology, economics, and politics. It was initially popularized by Tucker (1950) and used to simulate the real world, e.g., negotiations between countries, social interactions, war treaties, etc., where participants have the possibility of choosing between cooperative or defective (egoistic) actions. The main point in this game is analysing which of the previous two options is the most profitable for a rational player, concluding in many cases where defection which result in a better payoff, and therefore is the most rational option.

The n-player prisoner's dilemma is an extension of the classic case where an individual interacts with more than one opponent at a time. It is interesting to explore cooperation in a social group. Multiple agents ($N \geq 2$) interact within their designated group and must choose to cooperate or defect. There may be individuals who take advantage of the efforts of others. If only one individual decides not to cooperate, it can take advantage of the rest. However, if many members of the group choose the defection strategy, the group benefits are dramatically reduced, and the existence of these free riders becomes clearly evident.

In this section, a social network-based model in which players initially play some independent games based on their self-interests and social ties has been presented. Interaction takes place between players who have cooperated previously, which again reflects those players who seek interaction with players who are more reliable. Thus, a game of n-player prisoner’s dilemma is proposed in which evolving cooperation is implemented by using the social network model developed by Rezaei, Kirley and Pfau (2009).

In the Rezaei, Kirley and Pfau (2009) model, the cost and benefit values remain the same throughout all games. Multiple sets of players are made to play the multi-player prisoner's dilemma game. Essentially, P is the total number of agents available to play the games, of which n-players are chosen for each game g. Initially, the players are chosen randomly and are updated in subsequent games according to the links established by individual players through their cooperation or defection in the game. However, to investigate cooperation in a social group (of hospitals in a health system), the games must have more than two players. The algorithm for n-player prisoner’s dilemma is shown in Figure 4.11

Figure 4.11: Algorithm for n-player prisoner's dilemma adapted from Rezaei, Kirley and Pfau (2009)

Algorithm 1: Social Network Based N-Player Prisoner's Dilemma Model

---

Result: Population of agents P, evolutionary rate $e/in[0,1]$, number of iterations i_{max} , number of players per game $N \geq 2$.
for $i = 0\ to\ i_{max}$ **do**
  $G = \varphi$
  while g = NEXTGAME(P, G, N) **do**
    $G = G \cup \{g\}$
    g = FORMATION OF GAME(P, G, N)
    g = PLAYGAME(P, G, N)
    g = ADAPTLINK(P, G, N)
  end
  for $i = 0\ to\ |P| \times e$ **do**
    a, b = SAMPLE(P)
    FCOMPAREUTILITYSELECT(a, b)
  end
end

4.7.3.1 Formation of game

In this n-player prisoner's dilemma game, the players play some independent games based on their self-interest and social ties. Interaction takes place between players who have co-operated previously. This reflects those players who prefer to seek interaction with players who are more reliable. The population of agents P is partitioned into a disjoint set of size N, and each disjoint set forms a game. The first player is always selected randomly and is not assigned to any game till in a current iteration. All other N-1 slots can be filled with probability (ϵ) from the neighbourhood of a first player and with probability (1-ϵ) or if all the players from the neighbourhood have been assigned, then the slot can be filled randomly with the remaining population. Here ϵ regulates how often a player plays with their current local neighbourhood players or an unknown player from the remaining population. Usually, every player plays exactly one game per iteration. But sometimes, depending on the size of P and N, a single player might not play at all, or the last game might not reach a size of N. The algorithm for the formation of a game is shown in Figure 4.12

Figure 4.12: Algorithm for the formation of a game adapted from Rezaei, Kirley and Pfau (2009)

Algorithm 2: Formation of Game

Result: N player Group: g

Players in one game= N

$P_1 = \text{Sample}(\forall_{p\epsilon P}\ p.Is\ Assigned = True)$

for $i = 2\ to\ N-1$ **do**

  a(with probability)= $0(\epsilon)$ or $1(1-\epsilon)$

  if $a == 0$ **then**

    if $Neighborhood(P_1) \neq \varphi$ **then**

      $P_i = \text{Sample}\left(Neighborhood\left(\forall_{p\epsilon P, Neighborhood(P_1)}\ p.IsAssigned \neq True\right)\right)$

      $P_i.IsAssigned = Ture$

    else

      $P_i = \text{Sample}\left(NotNeighborhood\left(\forall_{p\epsilon P, Neighborhood(P_1)}\ p.IsAssigned \neq True\right)\right)$

      $P_i.IsAssigned = Ture$

    end

  else

    $P_i = \text{Sample}\left(NotNeighborhood\left(\forall_{p\epsilon P, NotNeighborhood(P_1)}\ p.IsAssigned \neq True\right)\right)$

    $P_i.IsAssigned = Ture$

end

4.7.3.2 Execution of the game

The outcome of every game depends on one of the following two strategies of each player:

(a) Pure strategies: Each player always plays cooperatively or defectively.

(b) Mixed strategies: Each player always plays cooperatively or defectively based on the probability.

The action taken by the player in a mixed strategy depends on the weights of the links w_{ij} it has established with each of its opponents $j \in g$ ($g \in G$) for the current game g. The average link weight for player i in game g is then defined as (Rezaei, Kirley & Pfau 2009):

$$\overline{w_i}(g) = \frac{1}{|g|}\sum_{j\in g} w_{ij} \quad \text{(4.8.1)}$$

A mixed strategic player i plays cooperatively in a game g with probability:

$$Pro_i(g) = \frac{\overline{w_i}(g)^{\alpha}+\beta}{\overline{w_i}(g)^{\alpha}+\beta+1} \quad \text{(4.8.2)}$$

With probability $1 - Pro_i(g)$, a player plays to defect. β determines the value of the probability if there are no links with its opponents. α determines the gradient of the probability. After every game, the players receive a payoff or utility based on the action of the opponents and themselves. The payoff or utility value calculation is done using the following equation (Rezaei, Kirley & Pfau 2009):

$$U = \begin{cases} \frac{b \times i}{N} - c & \text{if the player cooperated} \\ \frac{b \times i}{N} & \text{if the player defected} \end{cases} \quad \text{……………………………….. (4.8.3)}$$

After the game's rules have been set, the next step is the execution. The algorithm for the execution of the game is shown in Figure 4.13.

Figure 4.13: Algorithm for the execution of the game adapted from Rezaei, Kirley and Pfau (2009)

Algorithm 3: Play Game Execution of Game

Result: Utility Update Based on Action: N player Group
Defect= 1, Cooperation= 0
for P_i *selected in g* **do**
  if $P_i.strategy = Mixed$ **then**
    $P_i.Action = According\ to\ Equation.$ 2.2
  else
    $P_i.Action = P_i.Action$ (remain same)
  end
end
[defectors, cooperators] = Actions taken by $\forall_{P_i \text{ selected in } g}$
for $i : 1\ to\ length(cooperators)$ **do**
  $P_i.UtilityValue = P_i.UtilityValue + (\frac{b \times i}{N} - c)$
end
for $i : 1\ to\ length(defectors)$ **do**
  $P_i.UtilityValue = P_i.UtilityValue + (\frac{b \times i}{N})$
end

4.7.3.3 Adapt links

Players can form links by mutual consent, which prevents any defector influencing the selection of opponents for the defector's advantage. The actions of each player are observable by other players. Otherwise, weight adjustment is not possible. As shown in Figure 4.14, for every iteration, link weights w_{ij} are changed (Rezaei, Kirley & Pfau 2009):

$$w_{ij} = \begin{cases} w_{ij} + 1, & \text{if both i and j played cooperatively,} \\ 0 & otherwise. \end{cases} \qquad \text{…………….…………(4.8.4)}$$

Figure 4.14: Algorithm for the adaptation of links adapted from Rezaei, Kirley and Pfau (2009)

```
Algorithm 4: Adaptation of Links
Result: Update Weights: N player Group
[defectors, cooperators] = Actions taken by ∀P_i selected in g
for i : 1 to length(cooperators) do
    for j : 1 to length(cooperators) & i ≠ j do
        w_ij = w_ij + 1
    end
end
for i : 1 to length(defectors) do
    for j : 1 to length(defectors) & i ≠ j do
        w_ij = 0
    end
end
```

4.7.3.4 Strategy update mechanism

A form of cultural evolution based on imitation is used in the strategy update mechanism. At every iteration, $|P| \times e$ pairs the players randomly from the population. Then, the actual utility of players is compared. The weights and strategy of a player who has a lower utility value are replaced with the weights and strategy of a player with a higher utility value. The new player will have 1 weight with the higher utility player and unique utility value. This models the successful imitation of strategies and trust within networks. The algorithm for the adaptation of links and strategy update is shown in Figure 4.15.

Figure 4.15: Algorithm for the adaptation of links and the strategy update mechanism adapted from Rezaei, Kirley and Pfau (2009)

Result: Update $|P| \times e$ pairs.
for $i = 0\ to\ |P| \times e$ **do**
  $a, b = \text{SAMPLE}(P)$
  if $a.UtilityValue \geq b.UtilityValue$ **then**
    $\forall_{j\epsilon\{1,2,\ldots,N\}} w_{b_i j} = w_{a_i j}$
    $w_{b_i, a_i} = 1$
    $b.UtilityValue = 1$
    $b.action = a.action$
  else
    $\forall_{j\epsilon\{1,2,\ldots,N\}} w_{b_i j} = w_{a_i j}$
    $w_{b_i, a_i} = 1$
    $a.UtilityValue = 1$
    $a.action = b.action$
  end
end

4.8 Summary of this chapter

In this chapter, the conceptual and theoretical foundations of this study, the justification for using a multiperspective and multitheoretical framework, the research methodology and the game theoretic model of the organisation of healthcare service delivery using the policy implementation status were discussed. The next chapter presents the results, discussion, and implication of this research study.

CHAPTER 5: RESULTS AND DISCUSSION OF FINDINGS

"The average length of stay in hospitals is often regarded as an indicator of efficiency in health service delivery. All else being equal, a shorter stay will reduce the cost per discharge and will shift care from inpatient to less expensive settings. Longer stays can be a sign of poor care coordination, resulting in some patients waiting unnecessarily in hospital until rehabilitation or long-term care can be arranged. At the same time, some patients may be discharged too early, when staying in hospital longer could have improved their health outcomes or reduced chances of re-admission."(OECD 2019, p. 196)

5.1 Introduction

This study focuses on healthcare service delivery shaped by strategic interactions among players (public hospitals) to improve public policy implementation. It borrows ideas from institutional design, structure-based organising or organisations, and system thinking in healthcare service delivery. The players are public hospitals as entities in which institutional design, structure-based organising or organisations, and system thinking is embedded. If policy implementation is to be improved (average length of stay is used for policy implementation), changes in institutional design (rules, clinical pathways, policies) would be desired. The public hospital system has many hospitals, and in each hospital, there are teams of healthcare professionals. Policy implementation success in one hospital does not mean success for the whole system. This is why, in this study, the model seeks to improve the policy implementation in each hospital as well as for the whole system. The expected outcomes of the three approaches to organising or organisation, as revealed by the literature review, are quality and the effective and efficient delivery of patient-centred healthcare services. The literature review also revealed that the principal-agent paradigm is an ideal way to implement policy.

Chapter 4 unpacks: (a) the game theoretical model and the conceptual foundations thereof; (b) the description of the policy implementation status and bureaucratic capacity computations;

and (c) the environment of the game, players, strategies, payoffs, and algorithms used in MATLAB. The results of the two models and their implications are discussed in this chapter.

Section 5.2 describes the datasets used in this study.

Section 5.3 presents the visualisation of data.

Section 5.4 discusses the results of the public hospitals' prisoner's dilemma game.

Section 5.5 discusses the results of the public hospitals' prisoner's dilemma game with evolving cooperation.

Section 5.6 presents the discussion of the findings.

Section 5.7 summarizes this chapter.

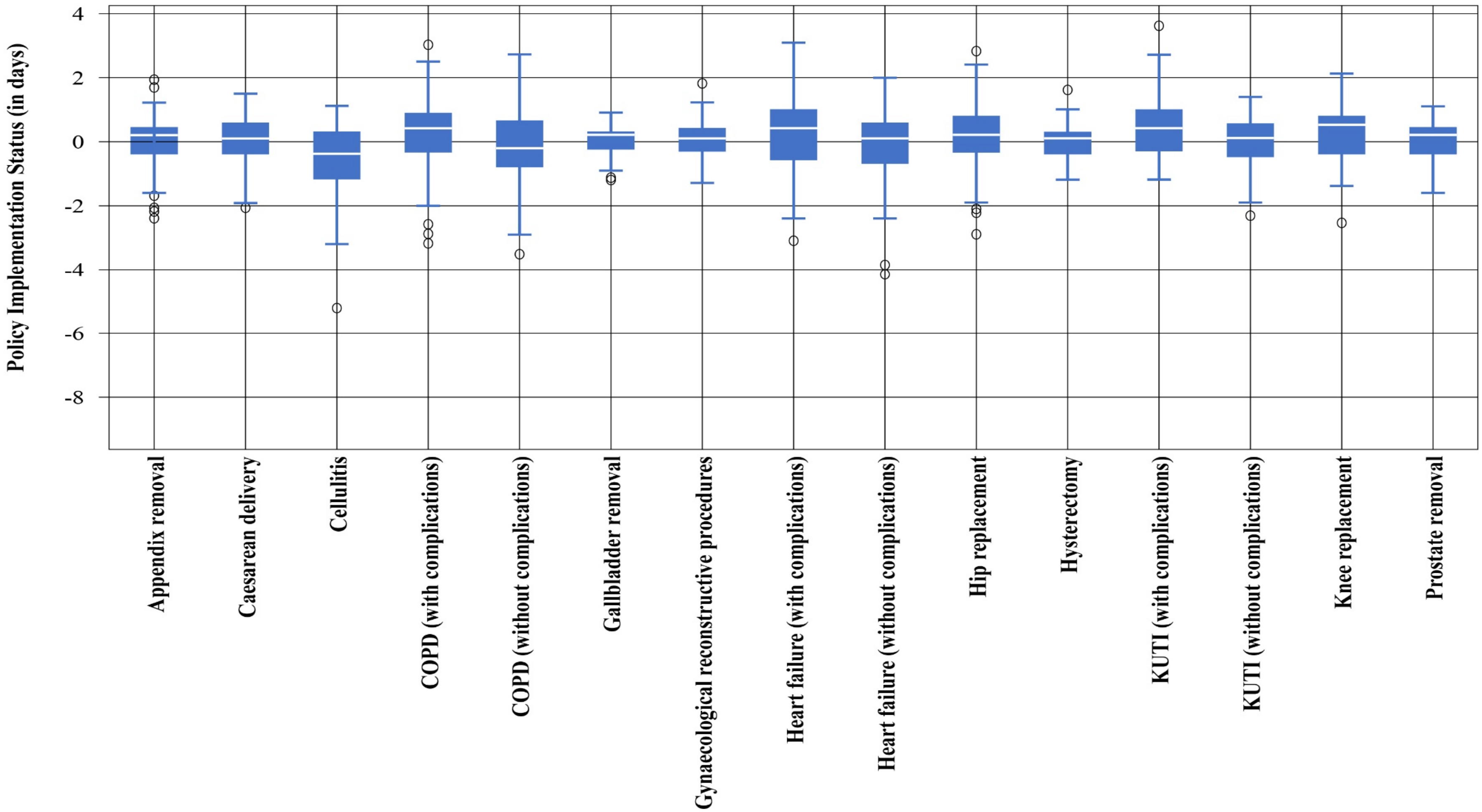
5.2 Summary of datasets

The average length of stay (ALOS) for the following health conditions has been selected for the game theoretic modelling in this chapter: (1) appendix removal; (2) caesarean delivery; (3) cellulitis; (4) chronic obstructive pulmonary disease with complications; (5) chronic obstructive pulmonary disease without complications; (6) gallbladder removal; (7) gynaecological reconstructive procedures: (8) heart failure with complications; (9) heart failure without complications; (10) hip replacement; (11) hysterectomy: (12) kidney and urinary tract infections with complications; (13) kidney and urinary tract infections without complications; (14) knee replacement; (15) prostate removal and (16) vaginal delivery. These procedures/treatments take up a significant part of healthcare service delivery. Although the model does not use the actual data, the ALOS data available on the *MyHospitals* portal of the Australian Institute of Health and Welfare has been used as a guide. Also, these are the only conditions included in the Australian healthcare datasets.

5.3 Visualisation of data

As described in the previous chapter, the policy implementation status of the public hospitals was calculated. Though some of the data may reflect the actual average length of stay, other data has been added to complete the sheet. This is why hospitals have been identified using numbers, such as, hospital 1, hospital 2, hospital 3 and so on. If the actual length of stay for a hospital and a particular health condition/treatment was lower than the average length of stay for the peer group and the same health condition/treatment, it is shown as a positive number, i.e., policy implementation efficiency (PiEf). If the actual length of stay for a hospital and a particular health condition/treatment was higher than the average length of stay for the peer group and the same health condition/treatment, it is shown as a negative number, i.e., policy implementation error (PiE). If the actual length of stay for a hospital and a particular health condition/treatment was the same as the average length of stay for the peer group and the same health condition/treatment, it is shown as a 0, i.e., a perfect policy implementation, also known as perfect bureaucratic capacity. The summary for public hospitals with the PiS for each hospital and health condition/treatment/procedure is shown in Appendix 1. Box plots illustrating four types of data, namely outliers, median, minimum, and maximum limits, are shown in Figure 5.1.

Figure 5.1: Policy implementation status across health conditions/treatments across hospitals



The number of patients is needed to calculate the patient bed days. For example, if the average length of stay for a particular health condition/treatment is 1.5, and the number of patients who received the treatment with an overnight stay is 150, the patient bed days would be 225 (150x1.5). Similarly, if the policy implementation status for a health condition/treatment is 0.4, and the number of patients who stayed overnight at the hospital is 100, the policy implementation status in days would be 40 (100x0.4). It was decided to simulate the number of patients (NoP) between 50-250, and then the data was frozen to ensure that it did not change while the MATLAB code was run. A snapshot of the number of patient data is shown in Appendix 2. A matrix plot of two health conditions/treatments (hip replacement and knee replacement) is shown in Figure 5.2. Box plots illustrating four types of data, namely outliers, medians, minimum and maximum limit are shown in Figure 5.3.

Figure: 5.2 A matrix plot of the data on the number of patients (NoP) for two health conditions

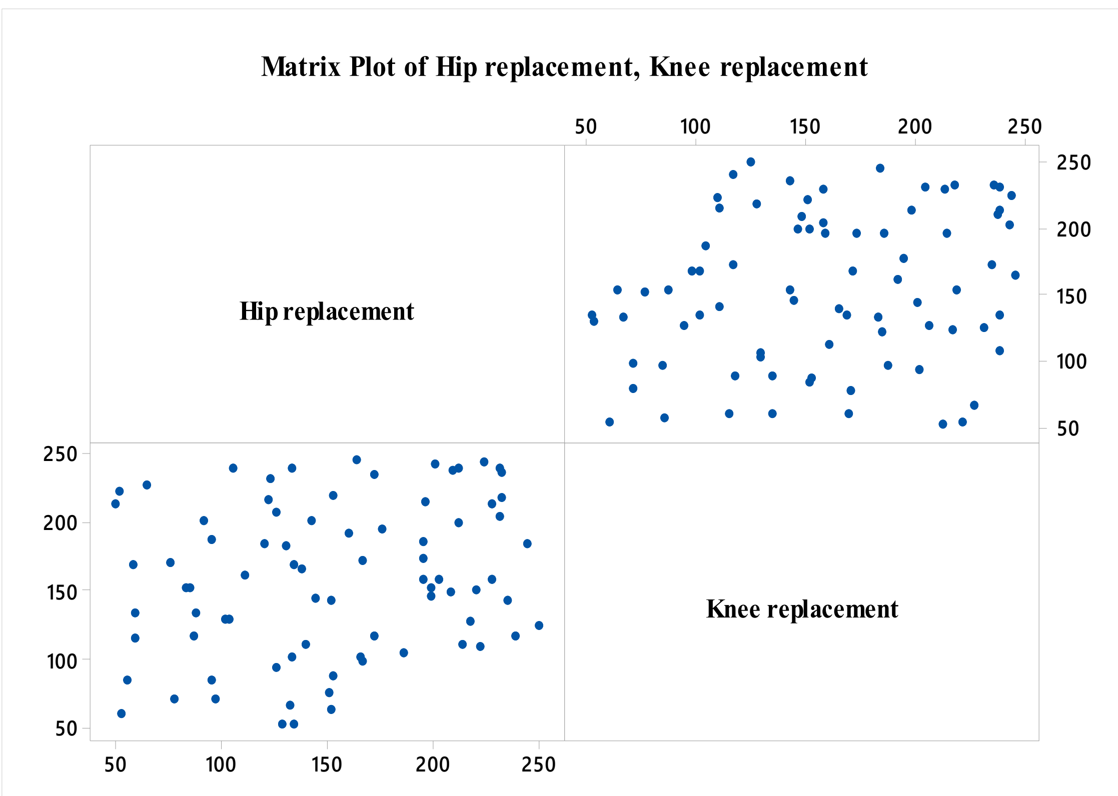
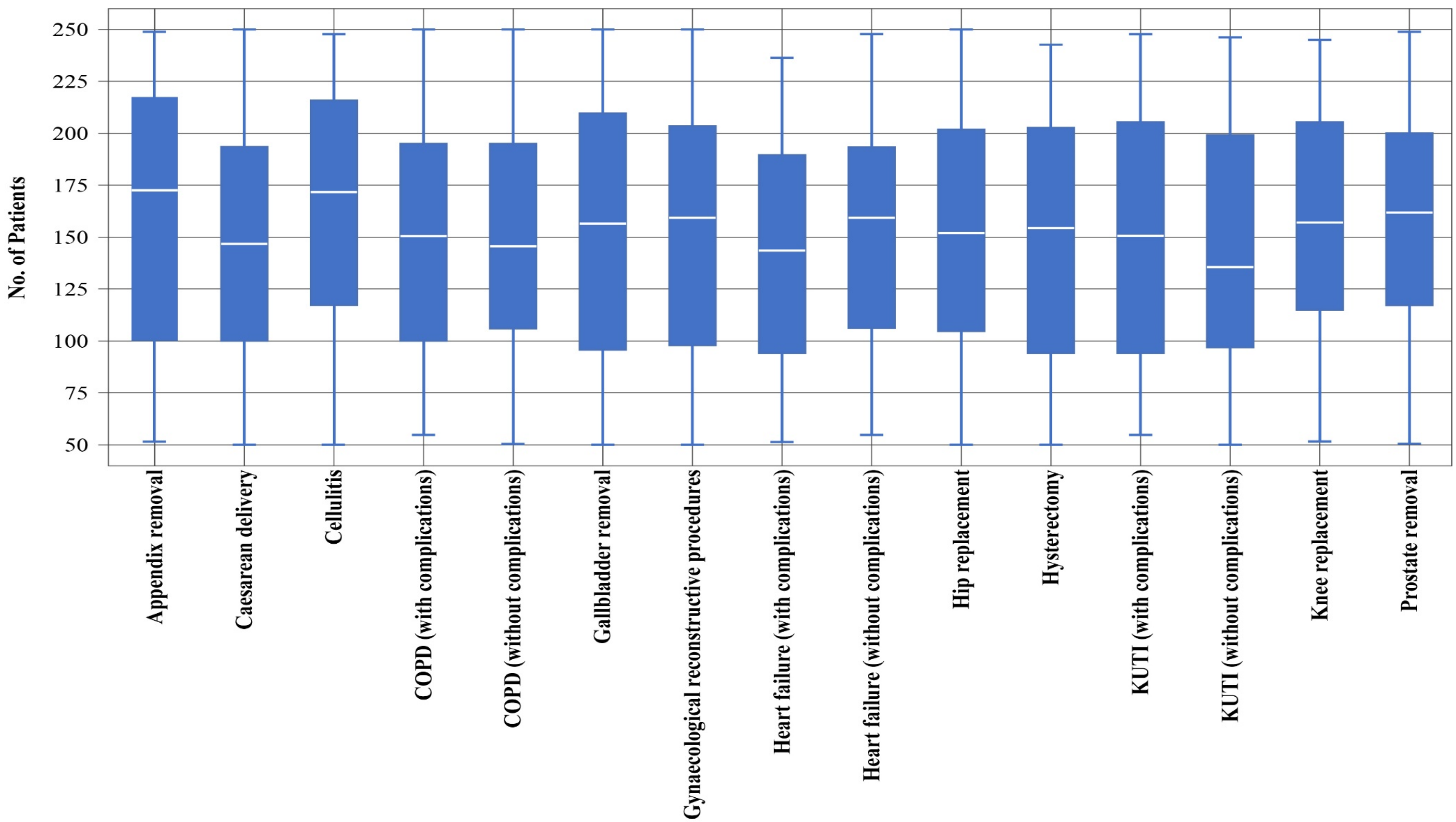


Figure 5.3: Number of patients against health conditions/treatments across hospitals



Per day cost of hospital stay is needed to calculate the total cost of a patient's stay in hospital. In other words, if the policy implementation status (in days) is multiplied by NoP, the result will be the policy implementation status in patient days. If the policy implementation status in patient days is multiplied by per day cost of hospital stay, the result will be the dollar value of the cost of the policy implementation status. For example, if the PiS is 0.6 days, the number of patients is 125, and the per day cost of hospital stay for one patient is \$3,250, the dollar value of the cost of PiS would be \$243,750. It was decided to simulate the per day cost (PdC) of hospital stay between \$3,250 and \$3,775, and then the data was frozen to ensure that it does not change while the MATLAB code is run. A snapshot of the PdC data is shown in Appendix 3. A matrix plot of hip replacement and knee replacement is shown in Figure 5.4. Box plots illustrating four types of data, namely outliers, medians, minimum and maximum limit are shown in Figure 5.5.

Figure: 5.4 A matrix plot of per day cost (PdC) data for two health conditions

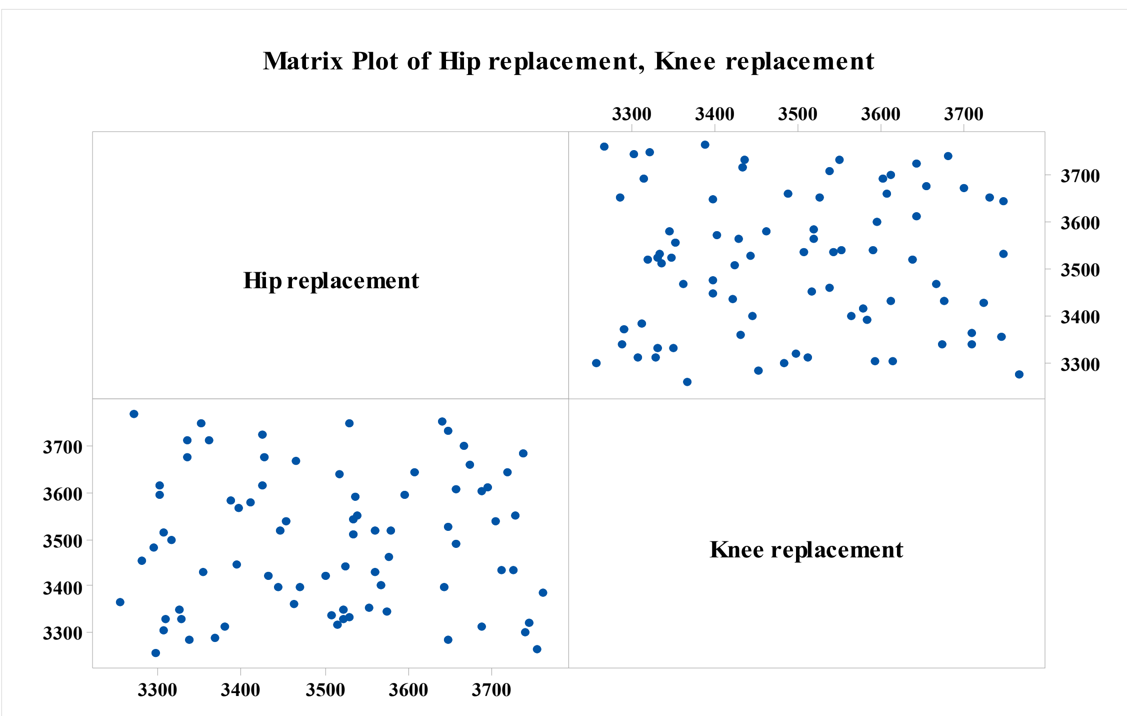
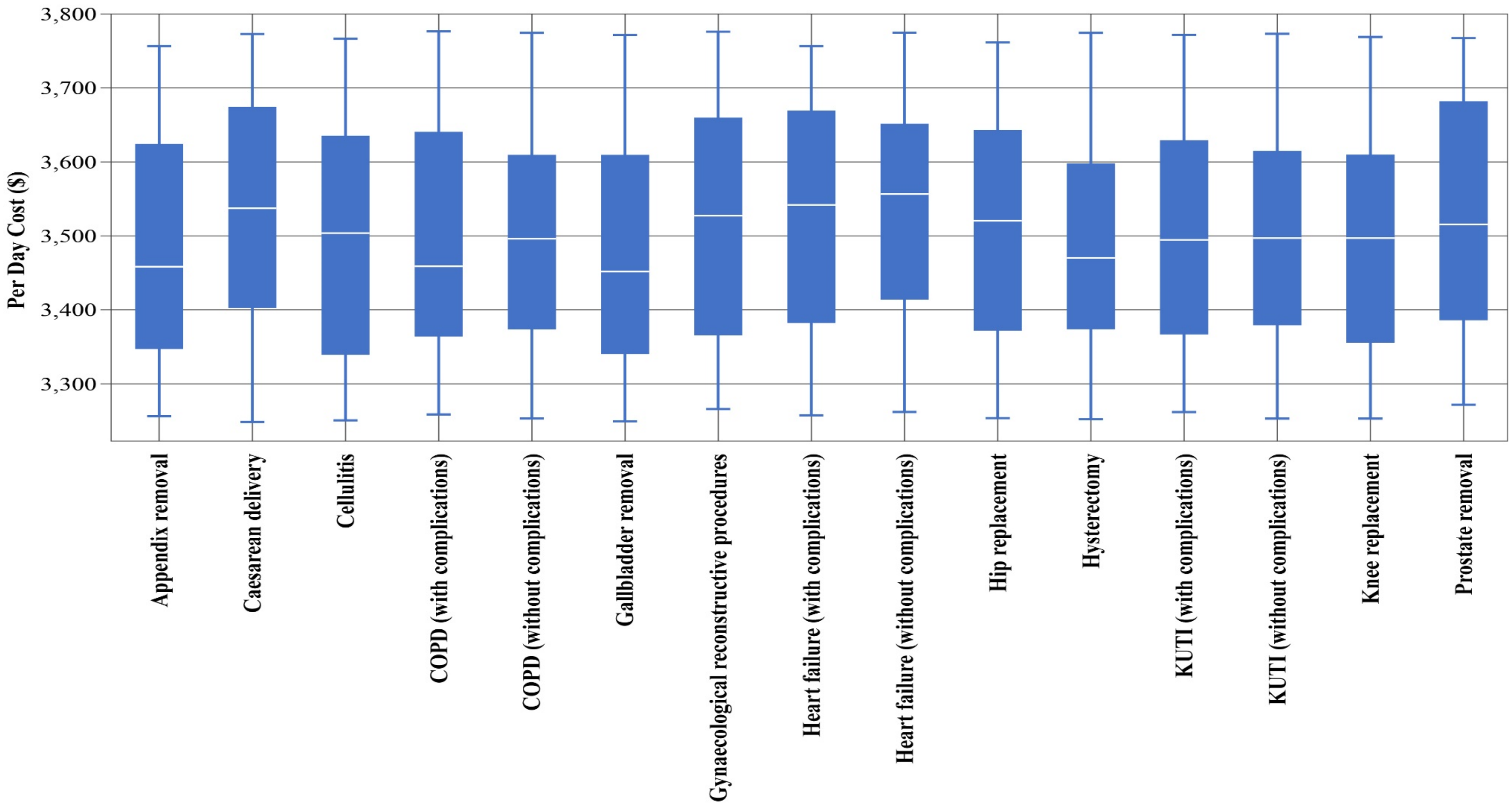
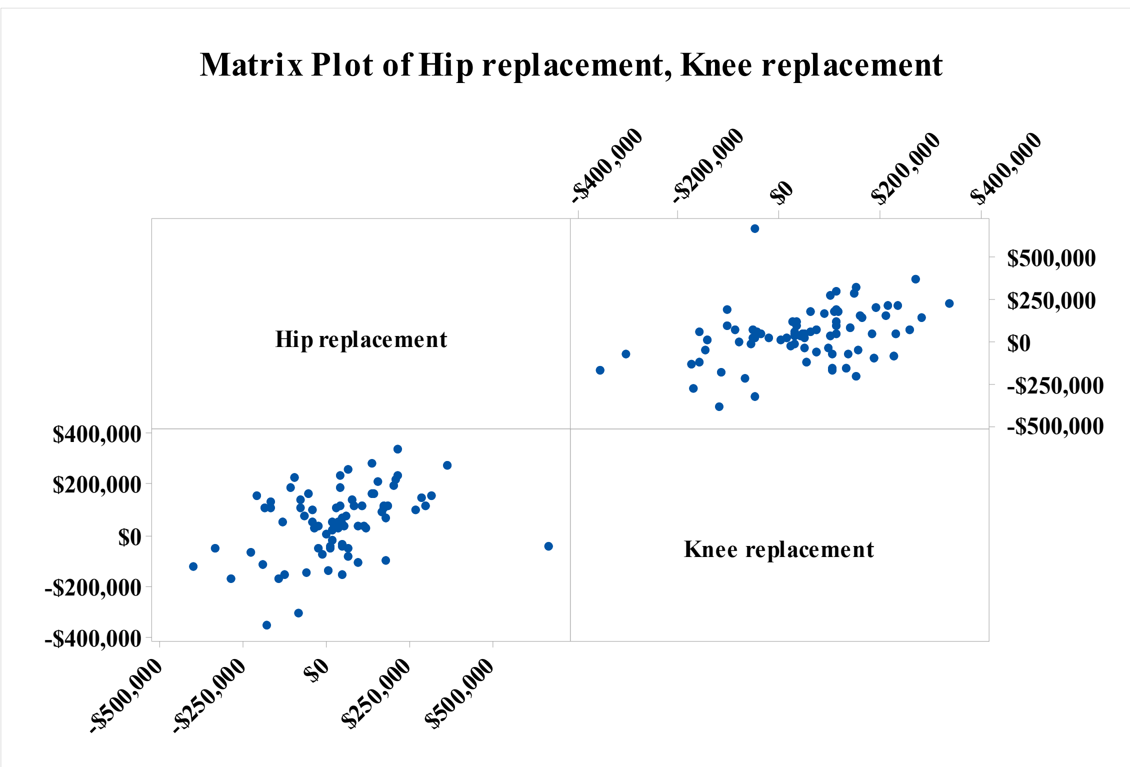


Figure 5.5: Per day cost (PdC) against health conditions/treatments across hospitals



Public hospitals in Australia are reimbursed by using the activity-based funding method. For the purpose of game theoretic modelling, it was decided to simulate per day revenue (PdR) between the range $4,150 and $4,850, and then freeze the data to ensure that it does not change when the MATLAB code is run. A snapshot of (PdR) data is shown in Appendix 4. The total revenue for patients' stays at the hospital is calculated by multiplying the policy implementation status (in days) by NoP and PdR. For example, if the PiS for a health condition/treatment is 0.3 days when NoP is 65, the total revenue would be $80,925 (0.3x65x4150), if the PdR is $4,150. Therefore, the net dollar value for a health condition would be the sum of (PiS*NoP*PdR) – (PiS*NoP*PdC) for all health conditions/treatments. A matrix plot net of the dollar value of the policy implementation of two health conditions/treatments (hip replacement and knee replacement) is shown in Figure 5.6.

Figure: 5.6 A matrix plot of net dollar value (PiS$) data for two health conditions



A policy implementation status summary of PiE, PiEf and perfect implementation i.e., perfect bureaucratic capacity is shown in Table 5.1

Table 5.1: Policy implementation status summary for each health condition/treatment

Health condition/treatment	Perfect Implementation	PiEf	PiE
Appendix removal	2	47	30
Caesarean delivery	1	44	34
Cellulitis	2	28	49
COPD (with complications)	0	49	30
COPD (without complications)	1	36	42
Gallbladder removal	5	46	28
Gynaecological reconstructive procedures	2	44	33
Heart failure (with complications)	1	47	31
Heart failure (without complications)	0	40	39
Hip replacement	1	51	27
Hysterectomy	1	43	35
KUTI (with complications)	0	55	24
KUTI (without complications)	2	41	36
Knee replacement	1	54	24
Prostate removal	4	47	28
Vaginal delivery	7	34	38

After calculating the net dollar value of the policy implementation status (PiS$) for each health condition/treatment, a sum of PiS$ for all health conditions/treatments was used for game theoretic modelling. Box plots illustrating four major types of data namely outliers, medians, minimum and maximum limit of PiS$ for each health condition/treatment are shown in Figure 5.7. A summary of the net dollar value of all health conditions or treatments is presented in Figure 5.8. A snapshot of the net dollar value of the policy implementation status (PiS) for all hospitals is given in Appendix 5.

Figure 5.7: A snapshot of the dollar value of the policy implementation status of each health condition/treatment for all hospitals

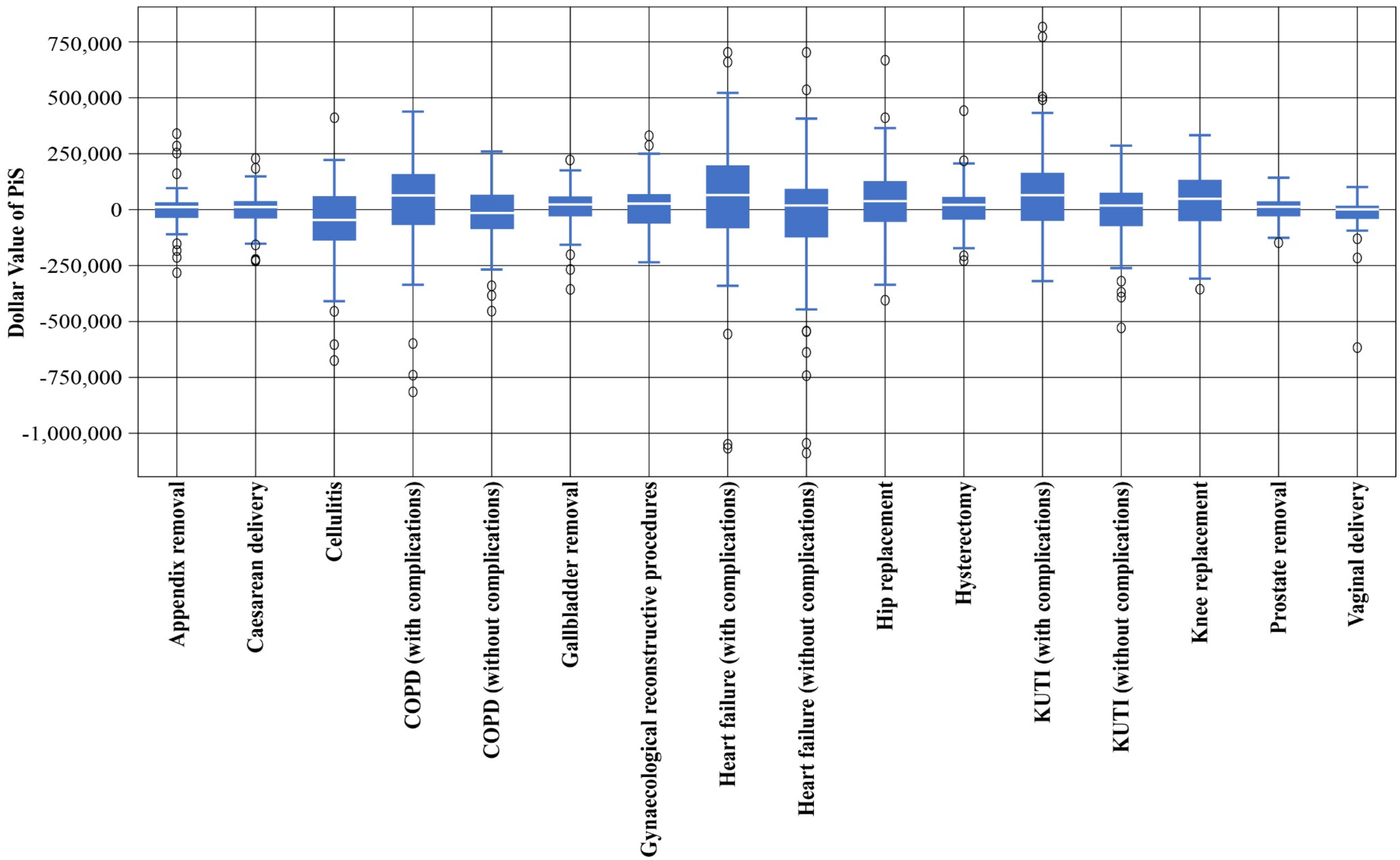
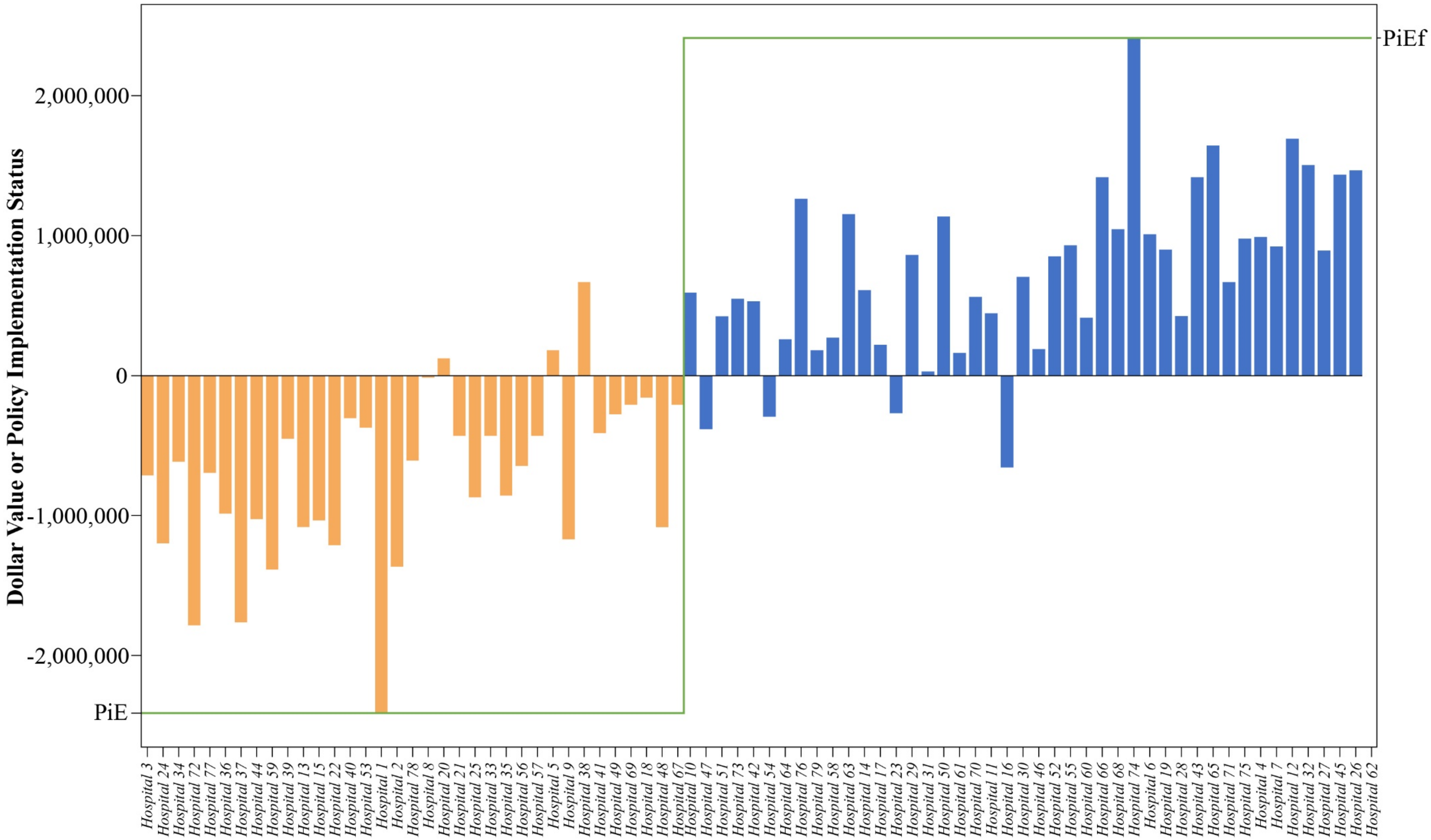


Figure 5.8: A snapshot of the dollar value of the policy implementation status of all hospitals



5.4 Results of the public hospitals' social or prisoner's dilemma game

Simulations are carried out for 25, 50, 100, 150, 175 and 200 rounds with the given 79 players (public hospitals). At the end of round 25 of the PiS for the procedure knee replacement, there were 41 defections. The players that have a negative PiS (PiE) are able to reduce it based on their score. The players that have a positive PiS (PiEf) are able to increase it further. Players' dollar value of PiS after round 25 is shown in Table 5.2.

Table 5.2: Results of the game (for 15 out of 79 players) after round 25

Hospital	PiS Knee Replacement	No of Patients	Per Day Cost	Per Day Revenue	Dollar Value of PiS	Cumulative Scores After 25 rounds	Scores in % (Out of Max Score 300)	Incentive/ Benefit in Dollars	New Dollar Value of PiS
1	(0.7)	116	3,611	4,500	(72,187)	100	33.33%	24,062	(48,125)
2	0.8	104	3,326	4,500	97,677	100	33.33%	32,559	130,236
3	(0.3)	150	3,347	4,500	(51,885)	100	33.33%	17,295	(34,590)
4	0.0	221	3,430	4,500	0	100	33.33%	0	0
5	0.2	173	3,675	4,500	28,545	0	0.00%	0	28,545
6	0.9	129	3,768	4,500	84,985	100	33.33%	28,328	113,314
7	1.4	110	3,516	4,500	151,536	200	66.67%	101,024	252,560
8	1.3	200	3,700	4,500	208,000	0	0.00%	0	208,000
9	(0.6)	127	3,330	4,500	(89,154)	0	0.00%	0	(89,154)
10	1.2	234	3,593	4,500	254,686	0	0.00%	0	254,686
11	1.5	98	3,731	4,500	113,043	0	0.00%	0	113,043
12	0.7	134	3,328	4,500	109,934	100	33.33%	36,645	146,578
13	1.9	142	3,507	4,500	267,911	0	0.00%	0	267,911
14	0.5	216	3,537	4,500	104,004	0	0.00%	0	104,004
15	0.2	237	3,612	4,500	42,091	200	66.67%	28,061	70,152

At the end of round 50 of the PiS for the procedure hip replacement, there were 24 defections. The players that have a negative PiS (PiE) are able to reduce it based on their score. The players that have a positive PiS (PiEf) are able to increase it further. The players' dollar value of PiS after round 50 is shown in Table 5.3.

Table 5.3: : Results of the game (for 15 out of 79 players) after round 50

Hospital	PiS Hip Replacement	No of Patients	Per Day Cost	Per Day Revenue	Dollar Value of PiS	Cumulative Scores After 50 rounds	Scores in % (Out of Max Score 500)	Incentive /Benefit in Dollars	New Dollar Value of PiS
1	(1.2)	239	3,694	4,500	(231,161)	100	20.00%	24,062	(207,099)
2	1.2	186	3,308	4,500	266,054	100	20.00%	53,211	319,265
3	(1.3)	220	3,325	4,500	(336,050)	100	20.00%	17,295	(318,755)
4	0.0	52	3,353	4,500	0	400	80.00%	0	0
5	(0.1)	195	3,335	4,500	(22,717)	100	20.00%	4,543	(18,174)
6	1.3	104	3,271	4,500	166,161	100	20.00%	33,232	199,393
7	1.4	214	3,445	4,500	316,078	200	40.00%	126,431	442,509
8	1.3	143	3,667	4,500	154,855	200	40.00%	61,942	216,797
9	0.3	218	3,528	4,500	63,569	0	0.00%	0	63,569
10	0.3	172	3,300	4,500	61,920	100	20.00%	12,384	74,304
11	1.2	167	3,646	4,500	171,142	200	40.00%	68,457	239,598
12	0.6	59	3,328	4,500	41,489	100	20.00%	8,298	49,787
13	1.6	235	3,533	4,500	363,592	0	0.00%	0	363,592
14	(1.3)	122	3,453	4,500	(166,054)	0	0.00%	0	(166,054)
15	0.2	209	3,425	4,500	44,935	300	60.00%	26,961	71,896

At the end of round 100 of the PiS for the procedure gallbladder removal, there were 10 defections. The players that have a negative PiS (PiE) are able to reduce it based on their score. The players that have a positive PiS (PiEf) are able to increase it further. The players' dollar value of PiS after round 100 is shown in Table 5.4.

Table 5.4: Results of the game (for 15 out of 79 players) after round 100

Hospital	Gallbladder removal	No of Patients	Per Day Cost	Per Day Revenue	Dollar Value of PiS	Cumulative Scores After 100 rounds	Scores in % (Out of Max Score 600)	Incentive /Benefit in Dollars	New Dollar Value of PiS
1	(0.6)	121	3,607	4,650	(75,722)	200	33.33%	24,062	(51,660)
2	0.0	88	3,769	4,650	0	400	66.67%	0	0
3	(0.6)	172	3,381	4,650	(130,961)	100	16.67%	17,295	(113,666)
4	0.3	216	3,359	4,650	83,657	500	83.33%	69,714	153,371
5	(0.5)	95	3,622	4,650	(48,830)	200	33.33%	4,543	(44,287)
6	0.1	219	3,767	4,650	19,338	400	66.67%	12,892	32,230
7	0.7	178	3,347	4,650	162,354	300	50.00%	81,177	243,531
8	(1.2)	145	3,480	4,650	(203,580)	200	33.33%	67,860	(135,720)
9	0.6	157	3,327	4,650	124,627	0	0.00%	0	124,627
10	0.2	247	3,732	4,650	45,349	300	50.00%	22,675	68,024
11	0.0	240	3,500	4,650	0	300	50.00%	0	0
12	0.9	228	3,570	4,650	221,616	200	33.33%	73,872	295,488
13	0.2	155	3,353	4,650	40,207	100	16.67%	6,701	46,908
14	(0.1)	233	3,392	4,650	(29,311)	0	0.00%	0	(29,311)
15	0.4	79	3,539	4,650	35,108	300	50.00%	17,554	52,661

At the end of round 150 of the PiS for the procedure appendix removal, there were 3 defections. The players that have a negative PiS (PiE) are able to reduce it based on their score. The players that have a positive PiS (PiEf) are able to increase it further. The players' dollar value of PiS after round 150 is shown in Table 5.5.

Table 5.5: Results of the game (for 15 out of 79 players) after round 150

Hospital	Appendix Removal	No of Patients	Per Day Cost	Per Day Revenue	Dollar Value of PiS	Cumulative Scores After 150 rounds	Scores in % (Out of Max Score 700)	Incentive /Benefit in Dollars	New Dollar Value of PiS
1	(0.4)	176	3,726	4,200	(33,370)	300	42.86%	24,062	(9,308)
2	0.5	215	3,625	4,200	61,813	500	71.43%	44,152	105,964
3	(1.2)	89	3,590	4,200	(65,148)	300	42.86%	17,295	(47,853)
4	(0.2)	160	3,318	4,200	(28,224)	500	71.43%	20,160	(8,064)
5	0.2	214	3,339	4,200	36,851	300	42.86%	4,543	41,394
6	(0.1)	231	3,491	4,200	(16,378)	500	71.43%	11,699	(4,679)
7	0.2	53	3,736	4,200	4,918	400	57.14%	2,811	7,729
8	0.7	64	3,520	4,200	30,464	400	57.14%	67,860	98,324
9	(1.6)	72	3,318	4,200	(101,606)	100	14.29%	14,515	(87,091)
10	1.2	96	3,360	4,200	96,768	500	71.43%	69,120	165,888
11	0.6	57	3,750	4,200	15,390	400	57.14%	8,794	24,184
12	0.7	235	3,622	4,200	95,081	500	71.43%	67,915	162,996
13	0.9	196	3,288	4,200	160,877	200	28.57%	45,965	206,842
14	1.9	202	3,311	4,200	341,198	400	57.14%	194,970	536,169

At the end of round 175 of the PiS for the procedure prostate removal, there were 2 defections. The players that have a negative PiS (PiE) are able to reduce it based on their score. The players that have a positive PiS (PiEf) are able to increase it further. The players' dollar value of PiS after round 175 is shown in Table 5.6.

Table 5.6: Results of the game (for 15 out of 79 players) after round 175

Hospital	Prostate Removal	No of Patients	Per Day Cost	Per Day Revenue	Dollar Value of PiS	Cumulative Scores After 175 rounds	Scores in % (Out of Max Score 800)	Incentive /Benefit in Dollars	New Dollar Value of PiS
1	0.3	126	3,612	4,150	20,336	400	50.00%	24,062	44,398
2	(0.8)	67	3,338	4,150	(43,523)	600	75.00%	32,642	(10,881)
3	(0.1)	121	3,342	4,150	(9,777)	300	37.50%	17,295	7,518
4	(0.3)	162	3,347	4,150	(39,026)	500	62.50%	20,160	(18,866)
5	0.3	107	3,716	4,150	13,931	500	62.50%	4,543	18,474
6	(0.1)	230	3,601	4,150	(12,627)	500	62.50%	11,699	(928)
7	0.0	145	3,301	4,150	0	400	50.00%	0	0
8	(0.4)	169	3,328	4,150	(55,567)	700	87.50%	67,860	12,293
9	0.6	101	3,707	4,150	26,846	200	25.00%	14,515	41,361
10	(1.6)	211	3,699	4,150	(152,258)	600	75.00%	114,193	(38,065)
11	0.0	219	3,407	4,150	0	500	62.50%	0	0
12	0.7	192	3,655	4,150	66,528	500	62.50%	41,580	108,108
13	(1.2)	118	3,643	4,150	(71,791)	300	37.50%	26,922	(44,869)
14	0.9	122	3,384	4,150	84,107	500	62.50%	52,567	136,674
15	0.2	221	3,767	4,150	16,929	500	62.50%	65,440	82,369

At the end of round 200 of the PiS for the procedure Caesarean delivery, there was 1 defection. The players that have a negative PiS (PiE) are able to reduce it based on their score. The players that have a positive PiS (PiEf) are able to increase it further. The players' dollar value of PiS after round 200 is shown in Table 5.7.

Table 5.7: Results of the game (for 15 out of 79 players) after round 200

Hospital	Caesarean Delivery	No of Patients	Per Day Cost	Per Day Revenue	Dollar Value of PiS	Cumulative Scores After 200 rounds	Scores in % (Out of Max Score 1000)	Incentive/ Benefit in Dollars	New Dollar Value of PiS
1	0.3	132	3,725	4,250	20,790	400	40.00%	24,062	44,852
2	(0.3)	141	3,595	4,250	(27,707)	700	70.00%	32,642	4,936
3	1.4	135	3,252	4,250	188,622	400	40.00%	17,295	205,917
4	(0.1)	184	3,740	4,250	(9,384)	600	60.00%	20,160	10,776
5	(1.2)	148	3,532	4,250	(127,517)	700	70.00%	4,543	(122,974)
6	0.1	62	3,449	4,250	4,966	500	50.00%	11,699	16,665
7	0.0	228	3,370	4,250	0	500	50.00%	0	0
8	(0.2)	127	3,644	4,250	(15,392)	700	70.00%	67,860	52,468
9	0.3	176	3,707	4,250	28,670	200	20.00%	14,515	43,185
10	(0.3)	219	3,738	4,250	(33,638)	600	60.00%	114,193	80,555
11	(0.1)	121	3,710	4,250	(6,534)	600	60.00%	3,920	(2,614)
12	0.2	189	3,638	4,250	23,134	600	60.00%	13,880	37,014
13	0.6	166	3,764	4,250	48,406	300	30.00%	26,922	75,328
14	0.8	120	3,564	4,250	65,856	600	60.00%	39,514	105,370
15	(0.9)	111	3,641	4,250	(60,839)	800	80.00%	65,440	4,601

The PiS$ for all hospitals (in the public hospital system) increased from $8,002,255 to $41,528,337 at the end of round 200, as shown in Table 5.8.

Table 5.8: PiS$ (for 15 out of 79 players) after round 200

Hospital	PiS$ for All Conditions	Cumulative Scores After 200 rounds	Scores in % (Out of Max Score 1000)	Incentive/Benefit in Dollars	New Dollar Value of PiS
1	(2,409,756)	400	40.00%	963,902	(1,445,854)
2	(1,365,330)	700	70.00%	955,731	(409,599)
3	(717,545)	400	40.00%	278,018	(439,527)
4	985,671	600	60.00%	591,402	1,577,073
5	176,703	700	70.00%	123,692	300,395
6	1,006,208	500	50.00%	503,104	1,509,312
7	919,489	500	50.00%	459,744	1,379,233
8	(11,410)	700	70.00%	7,987	(3,423)
9	(1,168,187)	200	20.00%	233,637	(934,550)
10	591,820	600	60.00%	355,092	946,912
11	441,614	600	60.00%	264,968	706,583
12	1,691,077	600	60.00%	1,014,646	2,705,723
13	(1,080,948)	300	30.00%	324,284	(756,664)
14	609,982	600	60.00%	365,989	975,971
15	(1,031,599)	800	80.00%	825,279	(206,320)

5.5 Results of the prisoner's dilemma game with evolving cooperation in a social network

Simulation is carried out for the population of size |P| = 1000 with e = 0.9 and strategy update probability e = 1/|P| = 0.001. Payoff values are b = 5 and c = 3, b is the benefit value and c is the cost of cooperation. A simulation is carried out for two strategies:

● Pure Strategy: The players will either cooperate or defect throughout all games. For this scenario, the population is initialized with 50% cooperators and 50% defectors.

● Mixed Strategy: The players will change their strategic action of cooperation or defection based on their connections with the opponents. In this scenario, the population is initialized with 33.3% cooperators, 33.3% defectors, and 33.3% mixed strategic players with $\alpha = 1.5$ and $\beta = 0.1$

Figure 5.9 plots the variation of the ratio of cooperation in the population with time for an increasing value of N when all the agents play with a pure strategy with $i_{max} = 1{,}000$. For N = 2, a high cooperation is observed with an increase in the number of iterations. For N=2, the ratio of cooperation varies, but increases gradually. The players carry on the game until the last iteration. For N=3, the rate of cooperation varies and intersects N=2 between iterations 400-500. The players carry on the game until the last iteration. For N=5, the rate of cooperation declines and reaches 0 before 400. For N=10, the rate of cooperation declines and reaches 0 before iteration 300. For N=15, the rate of cooperation declines and reaches 0 between iterations 200-300. For N=20, the rate of cooperation declines and reaches 0 between iterations 200-300. Therefore, the rate of cooperation can be ranked from better to worse as: N=2; N=3; N=5; N=20; N=15; and N=10.

Figure 5.9: Ratio of the cooperation vs time (iteration) for various values of N with imax = 1,000 for the pure strategy

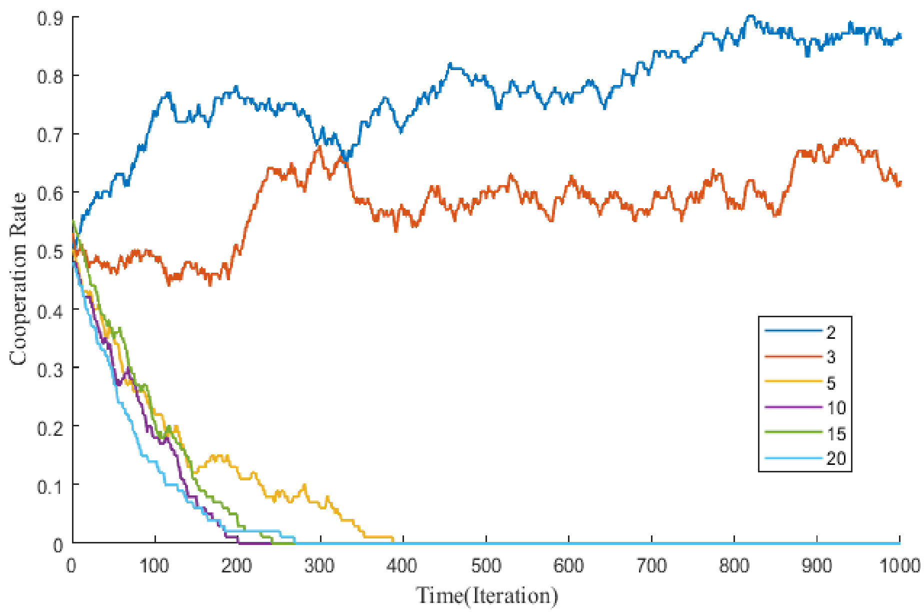


Figure 5.10 plots the variation of the ratio of cooperation in the population with time for an increasing value of N when all the agents play with a mixed strategy with imax = 1,000. For N = 2, a high level of cooperation is observed with an increase in the number of iterations. For N = 2, a high level of cooperation is observed with an increase in the number of iterations. For N=2, the ratio of cooperation varies, but increases gradually. The players carry on the game until the last iteration. For N=3, the rate of cooperation varies and intersects N=2. The players carry on the game until the last iteration. For N=5, the rate of cooperation varies and intersects both N=2 and N=3. The players carry on the game until the last iteration. For N=10, N=15 and N=20, the rate of cooperation increases slightly before declining and reaching 0 between iterations 200-400. Therefore, the rate of cooperation can be ranked from better to worse as: N=2; N=3; N=5; N=10; N=20; and N=15.

Figure 5.10: Ratio of the cooperation vs time (iteration) for various values of N with imax = 1,000 for the mixed strategy

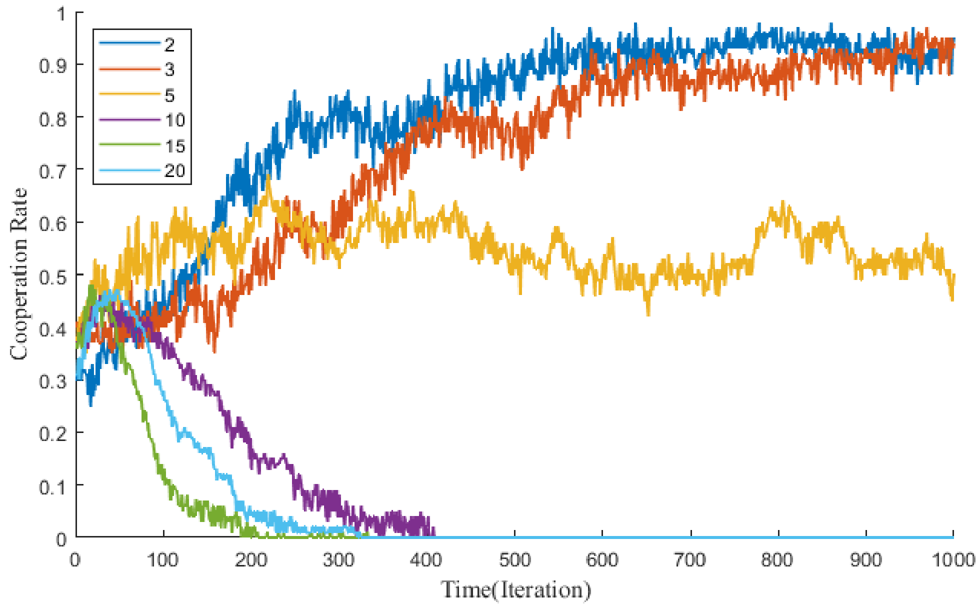


Figure 5.11 shows the same data with even a larger number of players with a pure strategy. In this scenario, 25, 50 and 100 players i.e., N = [25, 50, 100] have been chosen with imax = 400. For N=25, N=50 and N=100, the rate of cooperation increases, declines and then reaches 0. Interestingly, players in N=50 carry on the game until the last iteration. For N=50, the ratio of cooperation reaches 0 right before iteration 300. For N=100, the rate of cooperation reaches 0 before iteration 250. Therefore, the rate of cooperation can be ranked from better to worse as: N=50; N=25; and N=100.

Figure 5.11: Variation of cooperation ratio with time for N = [25, 50, 100] imax = 400 for the pure strategy

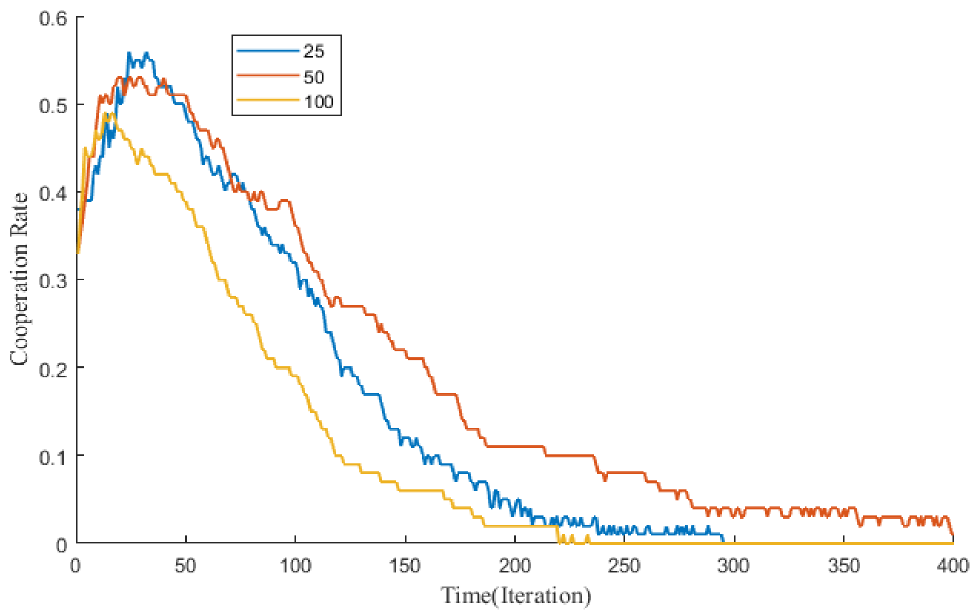
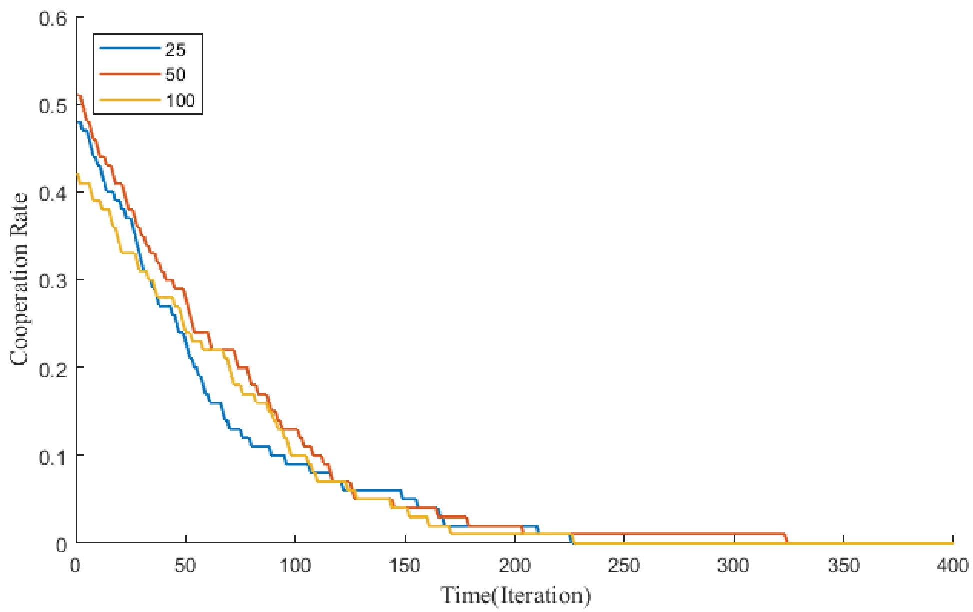


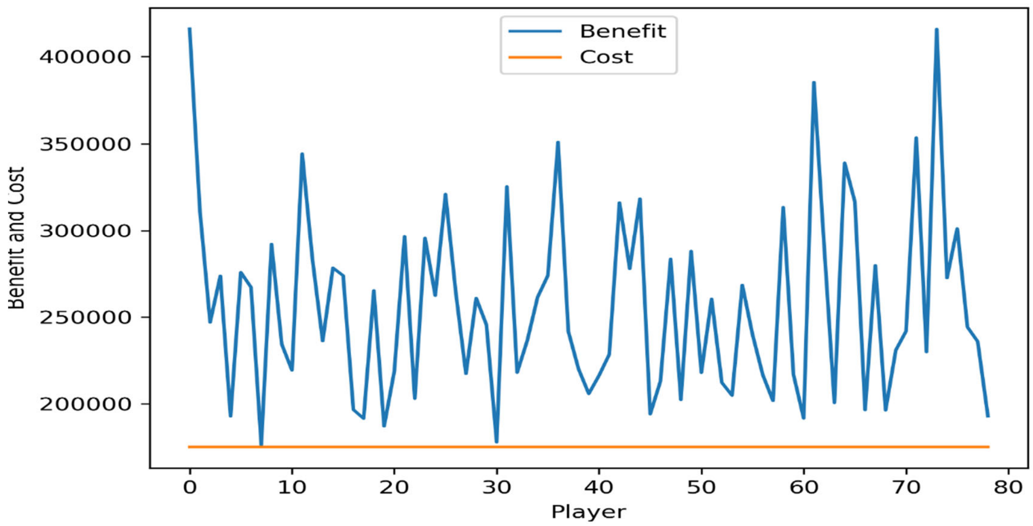
Figure 5.12 shows the same data with even a larger number of players with the mixed strategy. In this scenario, 25, 50 and 100 players i.e., N = [25, 50, 100] have been chosen with imax = 400. For N=25, the ratio of cooperation reaches 0 before iteration 250. For N=50, the rate of cooperation declines and reaches 0 between iterations 300-350. For N=100, the rate of cooperation declines and reaches 0 between iterations 200-250. Therefore, the rate of cooperation can be ranked from better to worse as: N=50; N=100 and N=25.

Figure 5.12: Variation of cooperation ratio with time for N = [25, 50, 100] imax = 400 for the mixed strategy



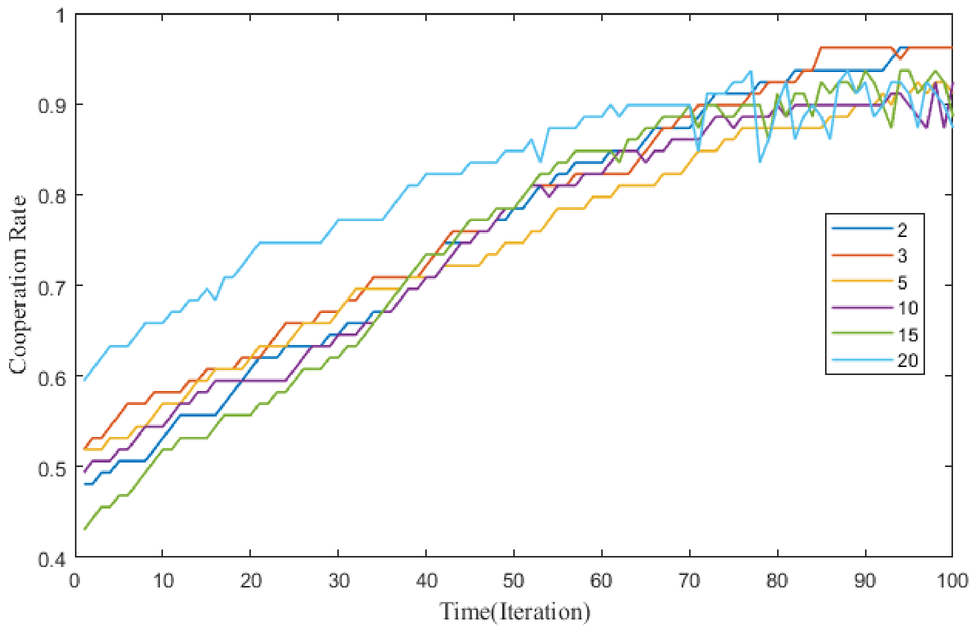
A player can get 10% of the dollar value of PiS (PiS$) for all conditions, plus reimbursement of the business improvement costs if it cooperates. If a player defects, it gets nothing. It has to bear the business improvement costs as the reimbursement of these costs is prohibited for defectors. To compute the benefit a player may receive, no differentiation is made between PiE and PiEf. For example, if a player has a PiE (a negative number) of $50,000, the maximum benefit it can get is 10% of $50,000 plus reimbursement of the business improvement costs. If a player has a PiEf (a positive number) of $80,000, the maximum benefit it can get is 10% of $80,000 plus reimbursement of the business improvement costs. To keep the game simple and manageable, it is assumed that the business improvement cost (C) or (c) for each player is $175,102. PiS$ varies as shown in Appendix 6. The cost and benefit of the players are shown in Figure 5.13.

Figure 5.13: Cost and benefit in dollars (total players =79)



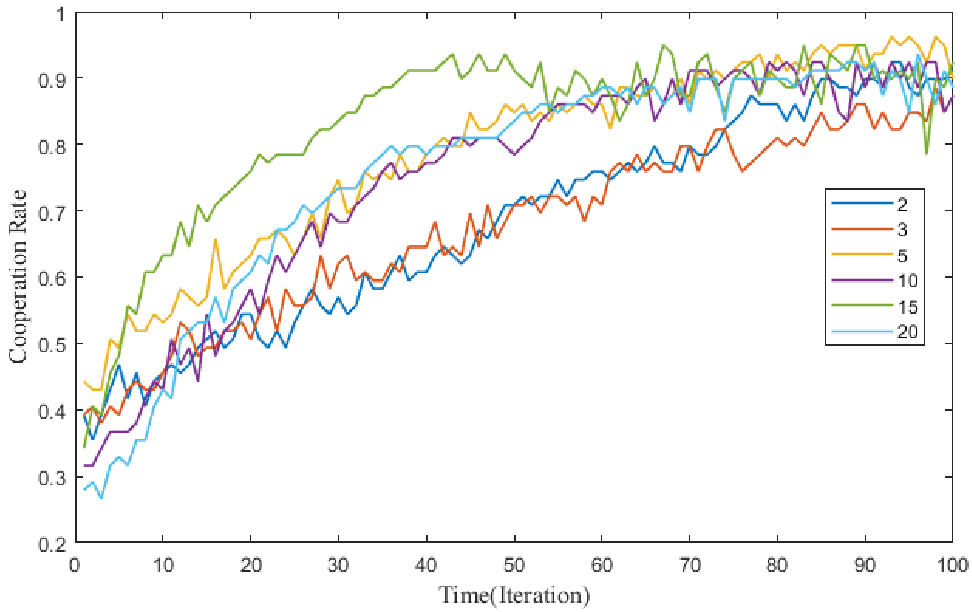
For the pure strategy, when the PiS$ for each player (hospital) is used, it is noted that N=2 is clearly in the lead, however, at the end of iteration 100, the groups of N=2 and N=3 are tied. In the beginning, the ranking (from better to worse) for the rate of cooperation, is N=2, N=3, N=5, N=10, N=20 and N=15. At the end of iteration 100, the ranking for the rate of cooperation is (from better to worse) N=2, N=3, N=10, N=5, N=15 and N=20. The cost of $175,002 remains the same from iterations 1 to 100. These results are shown in Figure 5.14.

Figure 5.14: Ratio of the cooperation vs Time (iteration) for various values of N with imax = 100 for the pure strategy (b= PiS$; c=175,002)



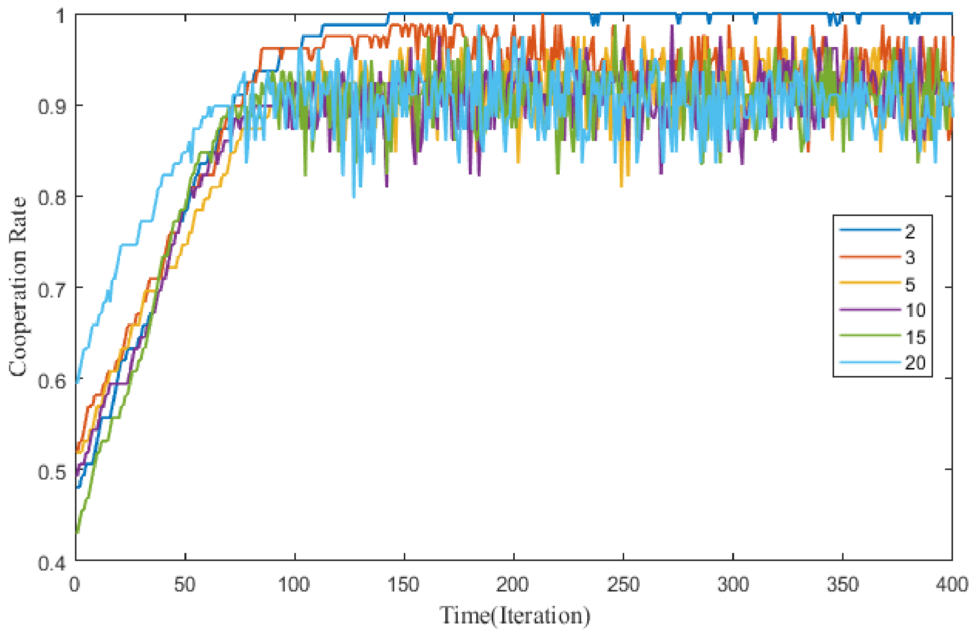
For the mixed strategy, when the PiS$ for each player (hospital) is used, it is noted that N=5 is clearly in the lead, however, at the end of iteration 100, the groups of N=2 and N=5, and N=3 and N=10 are tied. In the beginning, the ranking (from better to worse) for the rate of cooperation is N=5, N=3, N=2, N=15, N=10 and N=20. At the end of iteration 100, the ranking for the rate of cooperation is (from better to worse) N=15, (groups N=2 and N=5 are tied), N=20 and (groups N=3 and N=10 are tied). The cost of $175,002 remains the same from iterations 1 to 100. These results are shown in Figure 5.15.

Figure 5.15: Ratio of cooperation vs time (iteration) for various values of N with imax = 100 for the mixed strategy (b= PiS; c=175,002)



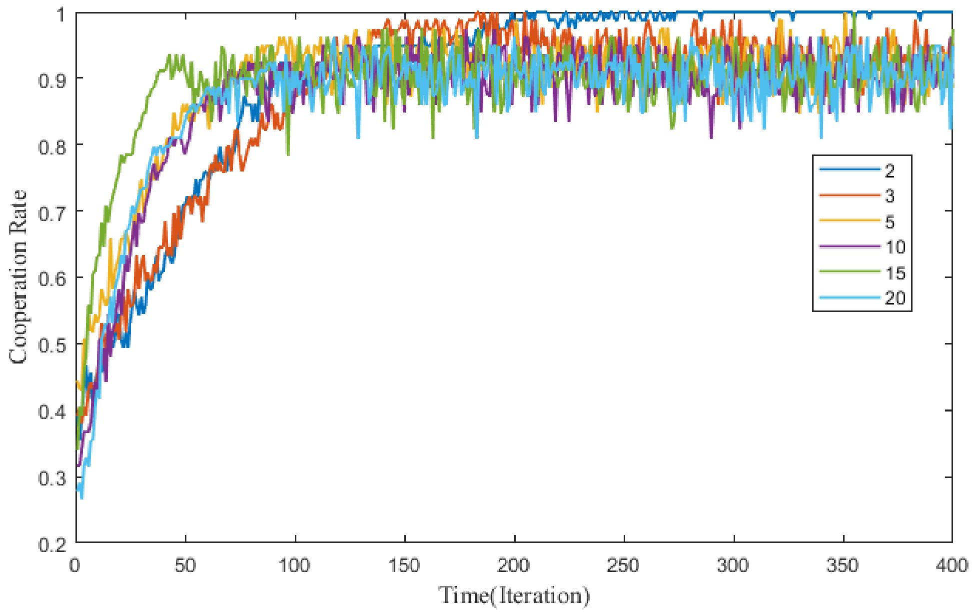
For the pure strategy, when PiS$ for each player (hospital) is used, it is noted that N=20 is clearly in the lead, however, at the end of iteration 400, all groups are close to each other. In the beginning, the ranking (from better to worse) for the rate of cooperation is N=20, N=3, N=5, N=10, N=20 and N=15. The cost of $175,002 remains the same from iterations 1 to 100. These results are shown in Figure 5.16.

Figure 5.16: Ratio of cooperation vs time (iteration) for various values of N with imax = 400 for the pure strategy(b= PiS; c=175,002)



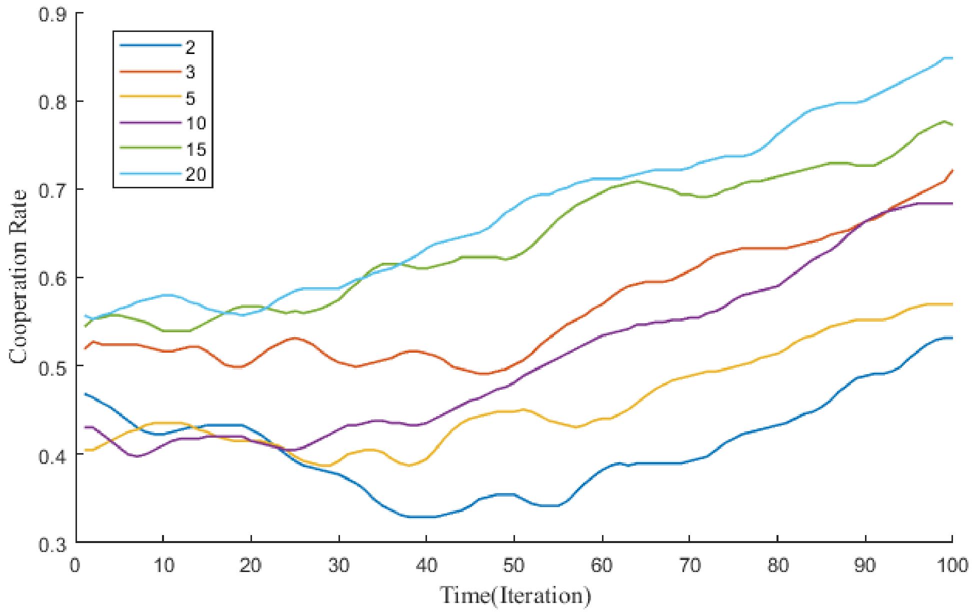
For the pure strategy, when the PiS$ for each player (hospital) is used, it is noted that N=5 is clearly in the lead, however, at the end of iteration 400, all groups are close to each other. In the beginning, the ranking (from better to worse) for the rate of cooperation is N=5, N=3, N=2, N=15, N=10 and N=20. The cost of $175,002 remains the same from iterations 1 to 100. These results are shown in Figure 5.17.

Figure 5.17: Ratio of the cooperation vs time (iteration) for various values of N with i_{max} = 400 for pure strategy (b= PiS; c=175,002)



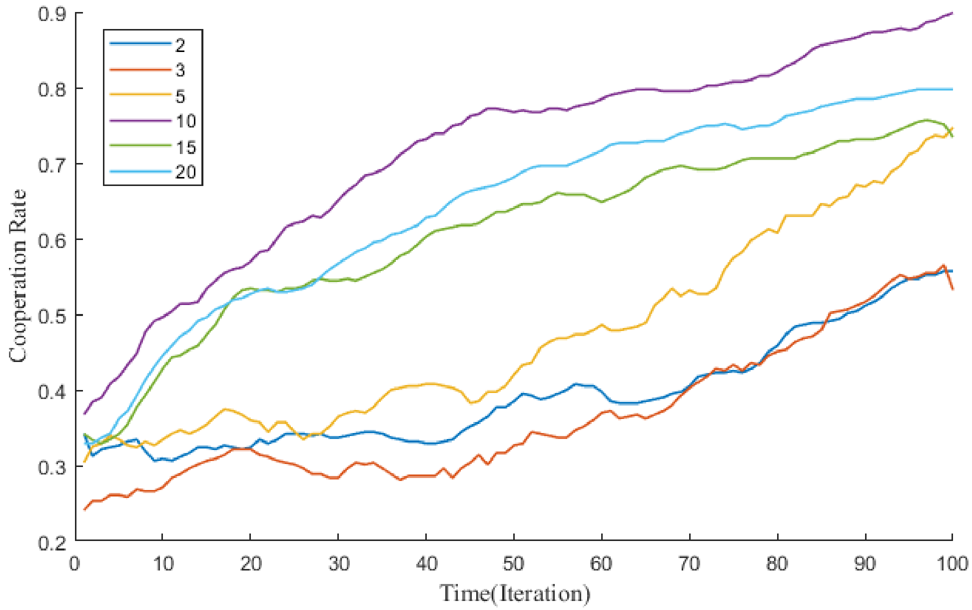
For the pure strategy, when a fixed PiS$ ($350,000) for each player (hospital) is used, in the beginning, the ranking (from better to worse) for the rate of cooperation is N=20, N=15, N=3, N=2, N=10 and N=5. At the end of iteration 100, the ranking for the rate of cooperation is (from better to worse) N=20, N=15, N=3, N=10, N=5 and N=2. The cost of $175,002 remains the same from iterations 1 to 100. These results are shown in Figure 5.18.

Figure 5.18: Ratio of cooperation vs time (iteration) for various values of N with i_{max} = 100 for the pure strategy (b= 350,000; c=175,002)



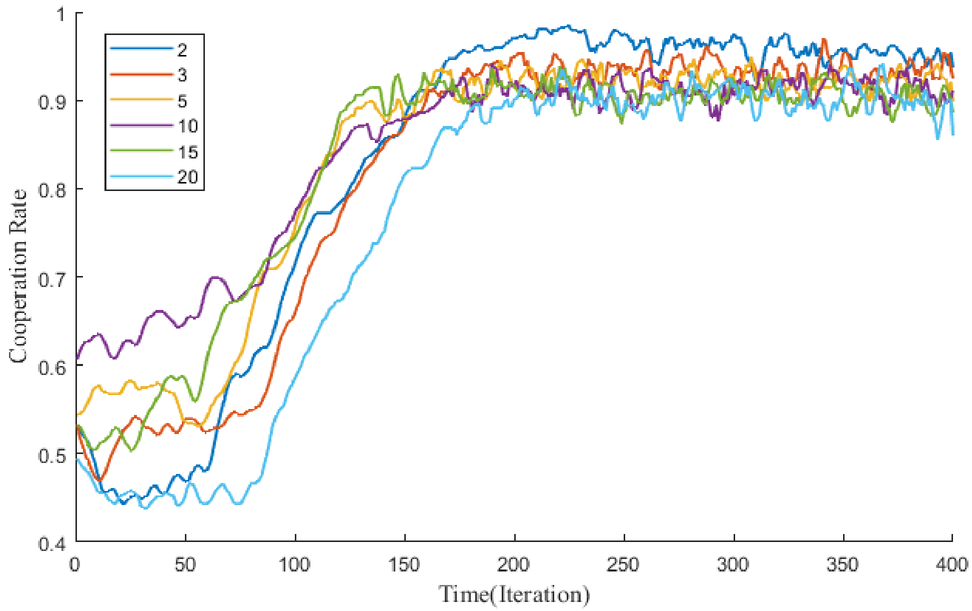
For the mixed strategy, when a fixed PiS$ ($350,000) for each player (hospital) is used, in the beginning, the ranking (from better to worse) for the rate of cooperation is N=10, N=2, N=15, N=20, N=5 and N=3. At the end of iteration 100, the ranking for the rate of cooperation is (from better to worse) N=10, N=20, N=5, N=15, N=2 and N=3. The cost of $175,002 remains the same from iterations 1 to 100. These results are shown in Figure 5.19.

Figure 5.19: Ratio of cooperation vs time (iteration) for various values of N with imax = 100 for mixed strategy (b= 350,000; c=175,002)



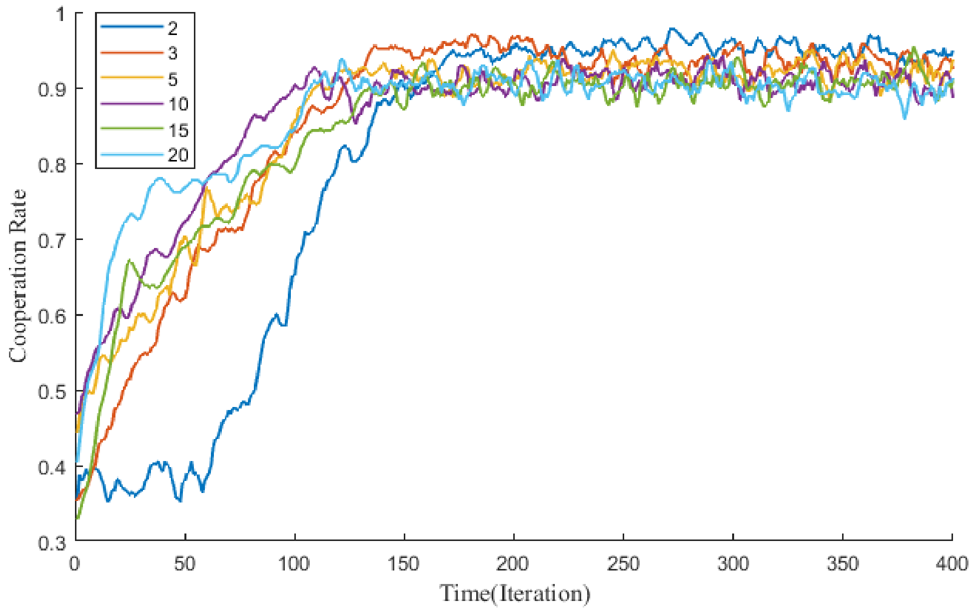
For the pure strategy, when a fixed PiS$ ($350,000) for each player (hospital) is used, in the beginning, the ranking (from better to worse) for the rate of cooperation is N=10, N=5, N=2, N=3, N=15 and N=20. At the end of iteration 400, the ranking for the rate of cooperation is (from better to worse) N=2, N=3, N=5, N=10, N=15 and N=20. The cost of $175,002 remains the same from iterations 1 to 100. These results are shown in Figure 5.20.

Figure 5.20: Ratio of the cooperation vs time (iteration) for various values of N with i_{max} = 400 for pure strategy (b=350,000; c=175,002)



For the mixed strategy, when a fixed PiS$ ($350,000) for each player (hospital) is used, in the beginning, the ranking (from better to worse) for the rate of cooperation is N=10, N=5, N=20, N=2, N=3 and N=15. At the end of iteration 400, the ranking for the rate of cooperation is (from better to worse) N=2, N=3, N=5, N=15, N=20 and N=10. The cost of $175,002 remains the same from iterations 1 to 100. These results are shown in Figure 5.21.

Figure 5.21: Ratio of the cooperation vs time (iteration) for various values of N with i_{max} = 400 for mixed strategy (b= 350,000; c=175,002)



5.6 Discussion of findings

This study presents two models highlighting the cooperation among players in a health system comprising many hospitals. Although the players are public hospitals, this study implicitly focuses on healthcare delivery by the members of interdisciplinary or multidisciplinary teams (physicians, surgeons, nurses, physical therapists, occupational therapists, social workers, and others involved in the delivery of healthcare services to patients). It is very important to understand the environment (e.g., rules, policy, procedures, and mechanisms used for the delivery of healthcare services) in which players (in this case, public hospitals) make strategic choices to maximize their payoff and achieve their organisational and professional goals.

The results of the model discussed in section 5.4 indicate that the more they (hospitals) play (engage with each other), the defection rate decreases. As the players engage more with each other, the competition increases because the players' performance is relative to the maximum points scored at the conclusion of a set of rounds, say 25, 50, 100 and so on. Therefore, early cooperation would increase a player's scores and also, the overall performance yields a higher benefit. If all the hospitals are encouraged to engage with each other, policy implementation can be improved. Engaging with each other means learning from each other. It also means learning from each other's mistakes. It may also mean exchanging clinical knowledge. Clinicians' role in improving performance has been recognised in the research (Veronesi, Kirkpatrick & Vallascas 2013). As public hospitals engage with each other, they need the expertise of healthcare professionals. For this, rules, regulations and clinical pathways are needed as indicated by institutional design (Goodin 1998).

In a public hospital system, hospitals do not need to compete with each other because all patients are covered by government insurance cover. However, it is in their best interests (and the interests of the general public) to engage with each other and reduce PiE. The Minister may introduce incentives and/penalties to encourage cooperation among hospitals. These results are consistent with the bundled payment program of the CMS in the United States (Clair, Iorio, Inneh, Slover, Bosco & Zuckerman 2015). The only difference is that in the United States, most hospitals are private. It is difficult (if not impossible) to encourage engagement among fierce competitors.

The Minister's task is made easier by the fact that all public hospitals are a part of the same system and they do not need to compete. They can collaborate and improve at the same time. The Minister has to ensure that institutional design bottlenecks (Mathauer & Carrin 2011) do not inhibit players' interactions. These results also support the demand for multitheoretical and multiperspective research because game theory alone many not be adequate to focus on: (a) the rules etc. (institutional design); (b) system thinking in which the smooth functioning of all subsystems (hospitals, clinical specialities, and non-hospital healthcare providers) is desired; and (c) the organisational structures for care coordination. Therefore, the Minister (the principal or social planner) has to adopt a holistic approach while setting the goals for public hospitals. As shown in Table 5.8, the system as a whole increased its PiS$ for all health conditions or procedures by 419% from $8,00,0255 to $41,528,337.

Section 5.5 shows the results of the Rezaei, Kirley and Pfau (2009) model in three scenarios: (a) when the model is run using b=5 and c=3; (b) when PiS$ are used -as shown in Appendix 6 as b while keeping c=$175,002; and (c) when PiS$ is a fixed sum (b=$350,000) and c=$175,002.

When using b=5 and c=3, the smaller the N, the better the performance. Only two players engaging in a group (N=2) achieve the best performance for the rate of cooperation under both the pure and mixed strategies where N=2, 3, 5, 10, 15 and 20. These results were obtained from 1,000 iterations and validate the findings in section 5.4, indicating that longer engagement (in terms of iterations) achieves better cooperation. However, if the number of players engaging in a group is small, better cooperation is achieved. If the same model is run for N=25, 50 and 100, different results are obtained. For the pure strategy, N=50 has the highest rate of cooperation, followed by N=25. N=100 has the worst rate of cooperation. For the mixed strategy, N=50 has the highest rate of cooperation, followed by N=100. N=25 has the worst rate of cooperation. For the pure strategy, the rate of cooperation increases at first, before declining for all three groups. For the mixed strategy, the rate of cooperation decreased with increasing iterations for all three groups. For the pure strategy, N=50 continues to engage until iteration 400. For the mixed strategy, none of the groups could go on beyond iteration 350. These results indicate that when the size of a group (N) is larger, the rate of cooperation decreases. Hence, it makes sense to keep the group smaller (preferably N<20). The Minister has to ensure that the rules of group formation (institutional design) are effective. As engagement among public hospitals continues, the Minister should be able to stop engagement in the interests of his objectives and for the improvement of the whole system.

While using PIS$ for each hospital as b and keeping c=$175,002, the model was run for

100 and 400 iterations. For the pure strategy and 100 iterations, N=2 and 3 have the best rate of cooperation, followed by N=10. For the mixed strategy with 100 iterations, N=15 has the best rate of cooperation, followed by N=2 and N=5 with the second-best rate of cooperation. For both strategies and 100 iterations, the rate of cooperation increases (and also intersects at different points) before stabilising. For both the pure and mixed strategies and 400 iterations, the cooperation rate for all groups varies after iteration 100. At different stages, different groups perform better in terms of the rate of cooperation. Also, these results do not support the finding of the previous scenario where small groups perform better because for pure and mixed strategies, N=20 and N=15 perform the best at the conclusion of the last iteration. However, if the iterations are limited to 100 or the social planner stops the engagement between 50-100 iterations, the results of the previous scenario are supported in that the rate of cooperation increases with iterations. The Minister has to not only watch the group size, but also the structure and rules need his attention.

While using b=$350,000 and keeping c=$175,002, the model was run for 100 and 400 iterations. For the pure strategy and 100 iterations, N=20 has best rate of cooperation, followed by N=15 and N=3 for the second and third best. For the mixed strategy with 100 iterations, N=10 has the best rate of cooperation, followed by N=20 and N=5 for the second and third best. For both strategies and 100 iterations, the rate of cooperation increases with an increase in iterations. For both the pure and mixed strategies and 400 iterations, the rate of cooperation for all groups varies after iterations 200 and 150 respectively. At different stages, different groups perform better in terms of the rate of cooperation. However, at the end of iteration 400, N=2 performs the best in both the pure and mixed strategies. If the iterations are limited to 150 or the social planner stops the engagement at 150 iterations, the results of the previous scenario are supported in that the rate of cooperation increases with the number of iterations.

5.7 Implications

The results of this study partially confirm the work done by Rezaei, Kirley and Pfau (2009). Smaller groups of players are expected to achieve a higher rate of cooperation. However, this was not the case when different benefits and cost amounts were used. It stresses the point that the Minister would have to observe the players and decide at what point best cooperation is achieved with a particular size of N. This is the only extent to which the results of this study can be compared to existing research as there are no game theoretic policy implementation studies in the healthcare domain. One important contribution this study makes is to highlight the importance of continuous engagement (interaction) among the players. In regard to generalisation, the findings of this study are in line with the bundled payment program of Medicare in the US (Clair et al. 2015; Siddiqi et al. 2017). This research study is unique in a way because the modelling is performed using hospital data, players, possible strategies, and a range of payoffs in a real-life scenario. Thus, it implicitly advances the goal of innovation in techniques and applications of empirical game theory as sought by Wellman (2006) by extending it to the healthcare research domain from computer sciences. Healthcare service delivery requires a careful examination of hospital performance data. If hospital performance data is modelled from a game theoretic perspective in which players and their strategies are analysed, an improvement could be achieved. The model used in this research study simulates the results based on average length of stay. A reduction in average length of stay not only reduces spending, it also frees up beds for the patients on a waiting list. It could become the foundation for the creation of a new regulatory framework. These findings open a possibility of using artificial intelligence and machine learning to predict the average of length of stay of a patient, based on his or her complete health profile.

5.8 Summary of the chapter

This chapter has underlined the importance of engagement among public hospitals to improve the policy implementation status. As the players play more rounds of the game, the policy implementation status is improved. An improvement in the policy implementation status would shorten the length of stay as the best performing engage with other hospitals. However, there is a caveat. The social planner (the Minister) would need to pay close attention to the size of the groups in each game and find a point where further engagement may not be necessary. The Minister would also need to focus on the rules (institutional design), the coordination inside a hospital as well as among the public hospitals, and organisational structure-related issues for smooth information flow and decision-making.

CHAPTER 6: CONCLUSION

"There is a lesson in the fact that simple reciprocity succeeds without doing better than anyone with whom it interacts. It succeeds by eliciting cooperation from others, not by defeating them. We are used to thinking about cooperation competition in which there is only one winner, competition such as football or chess. But the world is rarely like that. In a vast range of situations, mutual cooperation can be better for both sides than mutual defection. The key to doing well lies not in overcoming others, but in eliciting their cooperation." (Axelrod 1988, p. 191)

6.1 Introduction

This study was conducted to unpack the strategic interaction-driven organisation of healthcare service delivery by public hospitals. With this purpose in mind, the study identified the key role politicians and bureaucrats play in healthcare service delivery by public hospitals. Healthcare service delivery in general is a multidimensional and multidisciplinary activity. This study shows that public hospitals must cooperate with each other to deliver healthcare services. That will require collective efforts by the healthcare professionals, bureaucrats, and politicians. In order to achieve the objectives of this research study, a detailed analysis of players, payoffs and strategies was performed in the context of game theory. Their interactions are underpinned by different medical or surgical procedures with the ultimate goal of delivering quality healthcare services. Thus, this study uses theory integration to fill the gap left by the lack of multitheoretical research. Average length of stay encompasses not only a patient's condition, but how also how healthcare services are delivered. ALOS cannot be reduced without the cooperation of healthcare professionals. It will require rules (pathways), system (integrated healthcare delivery) and structure (for decision-making and strategic interactions).

Section 6.2 highlights the contribution of this study to the existing knowledge.

Sections 6.3 and 6.4 list the theoretical and practical implications of the research.

Section 6.5 presents the recommendations.

Section 6.6 specifies the limitations of this study.

Section 6.7 makes suggestions as to the direction of the future research.

Section 6.8 presents a gist of this study.

6.2 Contribution of the research

This study unpacks the different aspects of organising and organisation (as a verb). The institutional design approach to organisation highlights the role played by rules, policies, and procedures. The system approach is used to highlight the importance of a smooth functioning (e.g., care coordination) of systems and subsystems. In other words, each public hospital can be viewed as a system within the entire public hospital system. Any improvement in LOS will certainly require a smooth functioning of all systems and subsystems. A structure approach to organisation focuses on the relationships in a public hospital. While game theory is used to analyze the strategic interactions of different players, mechanism design helps with the development of an incentive and/or punishment regimen. Simply put, this study is an effort to promote a holistic understanding of healthcare service delivery by public hospitals.

To the best of the researcher's knowledge, it is the first endeavour to integrate two or more theories to build the conceptual foundation of a research study and also use one or more of the same theories for modelling. This research study also proliferates the well-established research paradigms as it does not have a purely positivist or interpretivist epistemological or ontological basis. This study also does not use a purely qualitative or quantitative or mixed research method. Instead, it first identifies gaps in the existing knowledge identified by the literature review and then thoroughly examines the Australian public healthcare system to identify what can be defined as the practical foundation of the model developed using MATLAB. It is not out of place to note that both theory integration and paradigm proliferation have been a focus of debate among scholars (Lather 2006; Mayer & Sparrowe 2013).

Chapter 3 seeks to achieve an understanding of the Australian healthcare system. Even though Australia has a hybrid healthcare system in which both public and private hospitals deliver healthcare services to patients, public hospitals are the backbone of the system as they are expected to provide healthcare to all Australian citizens and other individuals who are eligible to receive services from public hospitals. In essence, Australian public hospitals cannot refuse to provide healthcare services. Australian public hospitals have come under tremendous pressure as patients have to often wait for healthcare services. Average length of stay (ALOS) is directly related to the time patients have to wait because an optimised LOS would free up resources so that more patients can receive healthcare services. Due to technological and scientific advancements, hospitals are expected to shorten LOS. Such a movement is taking shape in other countries as health systems try to free up already scarce resources.

It has been argued by researchers that a single theory may not be able to answer all the research questions. A combination of one or more theories may be necessary to address complex research problems, such as healthcare service delivery by public hospitals. Due to the interdisciplinary nature of healthcare and the uncertainties that come with the delivery of healthcare services, it is desirable to find new ways to inquire into research problems in the healthcare domain. This is why this study depends on an unconventional way of conducting a research inquiry as most of the game theoretical studies revolve around a mathematical or computer model. This study uses theory integration and a real-life problem (ALOS) to develop the conceptual framework to develop two models that are solved using MATLAB. The two models presented in this study highlight the significance of cooperation among public hospitals.

6.3 Theoretical implications

This study seeks to contribute knowledge in the field of healthcare research (delivery of healthcare services) in four main areas:

(1) An important issue in the organisation or organising of healthcare service delivery has

been the lack of a comprehensive approach that includes more than one theory (Mick & Shay 2014b). Healthcare is a complex interdisciplinary field in which the patient is the central focus. Each patient's illness is unique and requires an individualised plan of treatment in an uncertain environment. This research study brings together theories (game theory and a simplified theory of mechanism design) and the three approaches to organisation or organising. This research study uses game theory for modelling.

(2) A systematic and multitheoretical examination of the organisation or organising of healthcare service delivery by public hospitals in general and Australian public hospitals in particular has escaped the attention of scholars. Game theory or the theory of mechanism design have so far been used for investigation and modelling in financial markets (Brinkman & Wellman 2016; Brinkman & Wellman 2017; Cheng, Liu, Amin & Wellman 2016); financial regulation (Cheng & Wellman 2017); strategic exploration and analysis (Jordan, Schvartzman & Wellman 2010; Vorobeychik & Wellman 2009); and risk minimisation (Jordan & Wellman 2009). This research study expands the field to include the delivery of healthcare services.

(3) This research study is unique in a way because the modelling is performed using hospital data, players, possible strategies, and a range of payoffs in a real-life scenario. Thus, it implicitly advances the goal of innovation in techniques and applications of empirical game theory as sought by Wellman (2006) by extending it to the healthcare research domain from computer sciences.

(4) This research study extends the Epstein and O'Halloran (1994), Huber and McCarty (2004), & McCarty and Meirowitz (2007) models of delegation, policy implementation error and bureaucratic capacity to healthcare research.

6.4 Practical implications

This study is significant for healthcare management practitioners and policy decision making in four aspects:

(1) Healthcare service delivery requires a careful examination of hospital performance data. If hospital performance data is modelled from a game theoretic perspective in which players and their strategies are analysed, an improvement could be anticipated. Such an approach could be useful if healthcare policymakers shift their focus from activity-based reimbursement to the bundled payment model as used by Medicare in the United States for certain services (Clair et al. 2015).

(2) The model used in this research study simulates the results based on average length of stay. A reduction in average length of stay would reduce spending and free up beds for patients on the waiting list. It could become the foundation for the creation of a new regulatory framework. Hospitals can be rewarded/punished based on the ALOS performance.

(3) Equally, the results of this study could help private hospitals in Australia and other countries reshape the delivery of healthcare services in a way which is both economical and effective.

(4) This study can be replicated in non-healthcare public and private enterprises to analyse payoffs based on performance indicators.

6.5 Recommendations

The findings of this research study raise some important issues in regard to the organisation or organising of healthcare service delivery by public hospitals as well as health policy formulation by the executive branch of the government, including bureaucrats. The following recommendations are made for public hospital management/administration and public policy makers:

(1) Healthcare delivery and public hospital performance should be linked to the success and failure of healthcare policy. If public hospitals are not able to improve their performance, there is a policy implementation error. When the public hospitals do not

meet the policy goals, changes in bureaucracy may have to be made.

(2) Public policy should be designed as such that public hospitals are incentivised to cooperate and penalised for non-cooperation. If hospitals see no benefit in non-cooperation, they will work as a social network. Public hospitals should be able to learn from each other and improve their performance. Large hospitals and teaching hospitals can lead the efforts in this regard.

(3) This study investigates one aspect of healthcare service delivery – average length of stay. Public hospitals should be encouraged and/or required to measure their performance as either policy implementation error or policy implementation efficiency or perfect policy implementation for Emergency Department wait time, surgery waitlists and patient outcomes (including patient satisfaction).

(4) It is necessary to make a fundamental change in the reimbursement method for healthcare services. Policy implementation status should be linked to the average length of stay, readmissions, patient satisfaction and overall efficiency. Public hospital funding should be for value (savings, better outcomes and patient satisfaction).

(5) Both models presented in this study could be used to plan at what point a game should conclude and what should be part of the players' strategies. For example, players' strategies could include knowledge sharing and learning from others' experiences/mistakes. Hospitals do not have the same level of expertise. The models presented in this study could be instrumental in capacity building.

6.6 Limitations of the study

Although this research study examines the delivery of healthcare services from different perspectives, it has the following limitations:

(1) For game theoretic modelling, real public hospital performance data is not necessary, however, access to Victorian Public Hospital data could have brought the models closer

to the real world. Sincere efforts were made to obtain the data from the Victoria Department of Health. Requests were even filed under the Freedom of Information laws. In the end, the requested data could not be obtained. There were no patient privacy issues involved, however the government was reluctant to provide public hospital performance data. The limited data that the government provided was not useful. Therefore, the data that is available to the public was used for this study. The data had to be adjusted to fit the scheme of this study.

(2) The theoretical and conceptual foundations of this study, as elaborated in chapter 4, have two dimensions: (a) organisation of healthcare service delivery underpinned by the three approaches (institutional design, system, and structure) and game theory, the theory of mechanism design and the principal-agent paradigm (delegation, policy implementation and bureaucratic capacity); and (b) the issues and problems of the Australian healthcare system. Therefore, this study neither relies on pure positivism nor pure interpretivism. It mixes the two and then goes forward with game theoretic modelling. This study also does not use the mixed method. This researcher is taking the liberty to describe this phenomenon as paradigm proliferation. Although paradigm proliferation is not a bad thing (Lather 2006), it is likely to expose a research endeavour to criticism. Paradigm proliferation can be risky as well.

(3) It is recognised that a single theory may not be adequate to answer all research questions (Dixit & Sambasivan 2019; Mayer & Sparrowe 2013). Therefore, this study makes an endeavour towards theory integration, multitheoretical and multiperspective research. A researcher takes risks when he or she tries to deviate from the path created by other researchers in the past. Thus, the strength of this study also gives birth to its limitations.

(4) In chapter 4, this study elaborates three issues: asymmetry of information, regulation, and signalling. However, it does not explicitly state how these three issues will be

incorporated in the strategic interaction among the players (hospitals). It assumes that these three issues will become a part of the engagement/interaction in the two game theoretic computer models presented in this study. This researcher feared that including mathematical models or qualitative methods to address the three issues explicitly in the game theoretic models will make it overly complex and unmanageable.

6.7 Direction of future studies

The limitations and findings of this multitheoretical and multiperspective study offer opportunities for future studies. Future research may consider pursuing one or more of the following avenues:

(1) Researchers may consider using a qualitative or quantitative or mixed method to fill the gaps left open by this study. For example, a researcher may use the case study method for theory building to highlight what the players' strategies can be and also what the engagement among hospitals would entail. A quantitative study may inquire into the relationship between the rate of cooperation among hospitals and their performance outcomes.

(2) Despite repeated demands for theory integration and paradigm proliferation, these two areas remain virtually unexplored in the field of management, public administration, and healthcare organisational research. There are many organisation theories that could be integrated to inquire into a variety of research problems.

(3) It would be difficult to achieve the goals of theory integration and paradigm proliferation until and unless purely conceptual research papers are produced. This requires the immediate attention of the scholars (MacInnis 2011; Yadav 2010).

(4) Although this researcher could not obtain access to comprehensive public hospital performance data, researchers in the future may try to build collaborations with the government in this regard. Patient satisfaction, outcomes and cost data would help

future researchers develop more models.

(5) The models used in this study could further be extended with the use of machine learning and artificial intelligence. For example, if researchers have access to patient profiles, they may be able to predict the length of stay of patients before admission based on their health conditions and the level of severity of their illness.

6.8 Summary

The research study finds that the cooperation among public hospitals (as players) is important for improvement in performance (as measured by policy implementation status in regard to average length of stay). The models used in this study clearly show cooperation among players increases as they engage with each other (as signified by the rounds of a game). With the increasing number of rounds, defections (noncooperation) decrease. If a social planner creates an incentive and punishment scheme, players will likely cooperate. Each hospital is a subsystem within a system (of all public hospitals in the state). This study validates the similar schemes used in other health systems (e.g., Medicare bundled payment in the US).

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APPENDIX 1

A snapshot of policy implementation status (PiS) data of 35 out of 79 hospitals

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Hospital	Appendix removal	Caesarean delivery	Cellulitis	Chronic obstructive pulmonary disease (with complications)	Chronic obstructive pulmonary disease (without complications)	Gallbladder removal	Gynaecological reconstructive procedures	Heart failure (with complications)	Heart failure (without complications)	Hip replacement	Hysterectomy	Kidney and urinary tract infections (with complications)	Kidney and urinary tract infections (without complications)	Knee replacement	Prostate removal	Vaginal delivery
2	Hospital 1	-0.4	0.3	1.0	0.5	-1.1	-0.6	0.6	-3.1	-1.7	-1.2	-1.2	-1.0	0.0	-0.7	0.3	-1.6
3	Hospital 2	0.5	-0.3	-3.0	-2.9	-0.2	0.0	0.1	-1.4	-0.4	1.2	-0.1	-0.5	0.3	0.8	-0.8	-0.2
4	Hospital 3	-1.2	1.4	-1.4	-0.3	-1.4	-0.6	0.9	0.5	1.3	-1.3	-0.8	-0.3	-1.2	-0.3	-0.1	-0.6
5	Hospital 4	-0.2	-0.1	0.2	1.9	0.9	0.3	0.4	2.7	0.5	0.0	0.1	0.8	0.2	0.0	-0.3	0.0
6	Hospital 5	0.2	-1.2	-1.8	-1.6	-0.2	-0.5	1.2	-0.3	0.5	-0.1	1.6	0.4	-0.3	0.2	0.3	0.9
7	Hospital 6	-0.1	0.1	0.0	0.3	0.2	0.1	0.5	1.6	-0.4	1.3	-0.3	0.5	0.0	0.9	-0.1	0.2
8	Hospital 7	0.2	0.0	0.0	0.2	0.8	0.7	-0.1	-0.8	0.2	1.4	0.2	0.5	0.6	1.4	0.0	-0.1
9	Hospital 8	0.7	-0.2	-0.3	-0.2	-1.4	-1.2	0.2	0.7	0.2	1.3	-0.5	-1.1	-0.4	1.3	-0.4	0.2
10	Hospital 9	-1.6	0.3	-2.4	-0.6	0.2	0.6	0.6	-0.6	-0.4	0.3	1.0	0.5	-1.1	-0.6	0.6	-3.1
11	Hospital 10	1.2	-0.3	-0.3	1.4	-2.8	0.2	-0.4	1.6	-0.9	0.3	-0.3	1.8	1.2	1.2	-1.6	0.3
12	Hospital 11	0.6	-0.1	-0.4	0.9	-0.2	0.0	0.2	0.8	0.4	1.2	-0.6	-0.4	0.1	1.5	0.0	0.0
13	Hospital 12	0.7	0.2	-0.4	1.5	0.5	0.9	0.1	1.9	1.1	0.6	-0.1	1.1	0.6	0.7	0.7	0.5
14	Hospital 13	0.9	0.6	-0.8	-0.6	-0.5	0.2	-0.2	-9.0	0.7	1.6	-1.2	-0.7	-1.2	1.9	-1.2	-0.1
15	Hospital 14	1.9	0.8	0.1	1.1	-1.9	-0.1	-1.2	2.3	-2.0	-1.3	1.0	0.2	1.2	0.5	0.9	0.6
16	Hospital 15	-0.5	-0.9	-1.1	-2.6	-0.6	0.4	-0.3	-0.6	-0.1	0.2	0.2	2.3	-0.2	0.2	0.2	-0.6
17	Hospital 16	-1.7	0.9	-1.4	0.2	1.4	0.2	0.2	0.2	-3.9	0.2	0.2	0.2	-1.0	0.2	0.2	0.2
18	Hospital 17	0.6	-0.9	0.2	0.2	1.0	0.2	0.2	0.2	-1.1	0.2	0.8	-0.7	-1.2	1.6	1.1	-0.7
19	Hospital 18	0.2	-0.6	-0.2	0.8	-0.6	-0.5	0.0	0.3	-0.8	-0.6	0.2	0.6	0.3	0.9	-0.5	-0.4
20	Hospital 19	0.1	0.2	-0.4	0.6	0.8	-0.4	0.5	0.7	0.5	2.0	0.2	-0.3	1.0	1.3	0.7	0.1
21	Hospital 20	1.9	-0.2	0.9	-0.9	-0.1	-1.1	1.8	1.7	-4.2	2.8	0.1	1.9	-0.2	-0.6	-0.9	-1.2
22	Hospital 21	-1.6	0.6	-1.4	-0.3	-0.5	0.2	-1.1	0.4	-0.5	-0.5	-0.5	0.1	-0.1	0.7	0.3	0.5
23	Hospital 22	0.3	-0.8	-2.7	1.8	-0.4	0.2	-0.5	0.7	-0.8	-2.9	0.3	-0.6	-2.3	-1.4	0.6	-0.5
24	Hospital 23	0.2	-2.1	-3.2	0.3	-1.9	0.8	0.1	-0.3	0.6	-0.6	0.6	0.2	0.8	0.3	0.4	0.8
25	Hospital 24	0.1	-0.4	-0.4	-3.2	0.8	-0.2	0.4	-0.3	-0.3	-2.1	-0.2	-0.3	-0.5	-0.9	0.9	-0.5
26	Hospital 25	-2.1	-1.9	0.4	0.4	-2.4	0.5	-0.8	0.4	0.4	0.2	0.6	-0.5	-0.3	-0.4	-0.5	-0.6
27	Hospital 26	0.5	0.2	0.1	1.6	1.2	0.7	-0.2	0.9	1.0	1.2	-0.4	1.0	0.5	0.5	0.0	0.0
28	Hospital 27	0.4	0.3	0.6	1.2	0.2	0.0	0.2	1.1	-0.4	0.8	-0.2	1.3	0.1	0.5	0.3	0.2
29	Hospital 28	0.2	0.6	0.5	1.3	1.4	0.6	-0.4	-0.5	0.4	0.2	0.2	0.2	-1.0	0.2	0.2	0.2
30	Hospital 29	0.1	-0.8	0.6	0.6	-0.2	0.3	0.7	-0.6	0.5	-0.3	0.6	2.7	0.3	0.8	0.9	-0.9
31	Hospital 30	0.3	-0.4	-1.2	0.9	1.4	0.5	0.3	1.3	0.7	0.5	0.3	1.2	-0.1	-0.5	0.2	0.2
32	Hospital 31	-0.6	0.7	0.3	0.4	-1.8	0.5	0.4	-0.6	-0.4	0.2	0.2	0.2	-1.0	0.2	0.2	0.2
33	Hospital 32	0.8	0.6	0.7	0.7	0.3	0.3	0.8	0.4	0.7	1.3	0.6	-0.3	0.6	0.5	0.7	-0.4
34	Hospital 33	-0.1	0.4	0.6	-0.8	-0.3	-0.9	0.4	-0.4	-1.3	-0.8	0.3	0.5	-0.3	0.8	0.8	-0.7
35	Hospital 34	-0.5	0.6	-0.7	-0.3	-0.7	0.3	0.9	-0.9	0.3	-0.2	-0.8	-0.6	-0.8	-0.4	-0.8	-0.4

APPENDIX 2

A snapshot of number of patients (NoP) data of 35 out of 79 hospitals

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Hospital	Appendix removal	Caesarean delivery	Cellulitis	Chronic obstructive pulmonary disease (with complications)	Chronic obstructive pulmonary disease (without complications)	Gallbladder removal	Gynaecological reconstructive procedures	Heart failure (with complications)	Heart failure (without complications)	Hip replacement	Hysterectomy	Kidney and urinary tract infections (with complications)	Kidney and urinary tract infections (without complications)	Knee replacement	Prostate removal	Vaginal delivery
2	Hospital 1	176	132	111	69	232	121	73	223	139	239	155	232	131	116	126	155
3	Hospital 2	215	141	166	208	60	88	225	123	191	186	101	93	231	104	67	188
4	Hospital 3	89	135	213	215	121	172	179	183	247	220	214	150	119	150	121	192
5	Hospital 4	160	184	235	92	175	216	65	92	55	52	210	95	149	221	162	117
6	Hospital 5	214	148	141	127	210	95	189	119	102	195	204	222	133	173	107	83
7	Hospital 6	231	62	88	243	110	219	233	226	71	104	172	82	50	129	230	64
8	Hospital 7	53	228	202	237	146	178	163	61	76	214	182	70	227	110	145	195
9	Hospital 8	64	127	69	63	104	145	203	204	175	143	181	95	88	200	169	57
10	Hospital 9	72	176	140	206	144	157	216	207	157	218	69	109	114	127	101	230
11	Hospital 10	96	219	211	198	195	247	179	58	182	172	198	148	70	234	211	209
12	Hospital 11	57	121	220	91	247	240	153	232	241	167	217	163	203	98	219	161
13	Hospital 12	235	189	79	141	51	228	204	128	167	59	81	196	201	134	192	53
14	Hospital 13	196	166	193	175	244	155	125	103	202	235	172	117	246	142	118	218
15	Hospital 14	202	120	68	180	233	233	99	210	203	122	93	225	66	216	122	57
16	Hospital 15	224	111	229	242	155	79	240	169	169	209	237	163	154	237	221	135
17	Hospital 16	245	213	61	65	68	118	239	190	243	95	93	75	127	187	148	166
18	Hospital 17	241	169	189	55	247	95	172	215	234	208	155	123	121	148	162	77
19	Hospital 18	155	236	58	131	116	199	51	168	101	244	144	55	155	183	240	121
20	Hospital 19	194	67	151	101	185	87	160	56	92	134	115	194	145	168	93	190
21	Hospital 20	226	135	233	142	229	248	71	172	201	222	92	107	115	109	70	108
22	Hospital 21	70	154	81	210	146	111	125	120	80	126	243	66	136	94	163	110
23	Hospital 22	183	241	181	157	93	79	89	72	174	56	131	150	197	85	245	130
24	Hospital 23	145	147	188	197	52	50	80	180	173	212	207	222	213	198	249	85
25	Hospital 24	100	135	151	152	115	96	237	52	115	199	67	129	98	151	177	174
26	Hospital 25	117	186	228	113	204	60	118	126	155	58	108	85	241	169	181	137
27	Hospital 26	141	90	220	200	231	225	195	185	94	129	239	117	147	53	116	82
28	Hospital 27	66	106	140	78	220	67	202	232	196	97	179	62	97	71	83	94
29	Hospital 28	188	65	203	133	68	100	98	54	110	140	237	74	167	110	219	164
30	Hospital 29	174	224	199	250	200	106	144	236	217	160	90	142	77	191	56	126
31	Hospital 30	134	140	224	171	155	178	161	139	166	153	52	91	68	218	202	192
32	Hospital 31	73	249	246	134	143	105	80	74	64	131	134	212	230	182	130	61
33	Hospital 32	79	217	248	75	114	210	245	155	99	231	79	96	78	204	147	121
34	Hospital 33	154	69	149	91	132	184	147	213	240	232	104	235	55	235	178	118
35	Hospital 34	232	69	212	151	152	214	196	91	162	65	51	205	161	226	196	117

APPENDIX 3

A snapshot of per day cost (PdC) of hospital stay data of 35 out of 79 hospitals

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Hospital	Appendix removal	Caesarean delivery	Cellulitis	Chronic obstructive pulmonary disease (with complications)	Chronic obstructive pulmonary disease (without complications)	Gallbladder removal	Gynaecological reconstructive procedures	Heart failure (with complications)	Heart failure (without complications)	Hip replacement	Hysterectomy	Kidney and urinary tract infections (with complications)	Kidney and urinary tract infections (without complications)	Knee replacement	Prostate removal	Vaginal delivery
2	Hospital 1	3,726	3,725	3,456	3,404	3,511	3,511	3,457	3,324	3,697	3,694	3,368	3,369	3,298	3,611	3,612	3,313
3	Hospital 2	3,625	3,595	3,338	3,304	3,343	3,343	3,444	3,557	3,754	3,308	3,488	3,515	3,386	3,326	3,338	3,295
4	Hospital 3	3,590	3,252	3,345	3,635	3,399	3,399	3,588	3,664	3,619	3,325	3,645	3,484	3,593	3,347	3,342	3,741
5	Hospital 4	3,318	3,740	3,397	3,434	3,405	3,405	3,744	3,379	3,690	3,353	3,456	3,477	3,370	3,430	3,347	3,373
6	Hospital 5	3,339	3,532	3,419	3,295	3,447	3,447	3,360	3,717	3,435	3,335	3,252	3,724	3,685	3,675	3,716	3,614
7	Hospital 6	3,491	3,449	3,599	3,540	3,410	3,410	3,477	3,398	3,746	3,271	3,463	3,331	3,694	3,768	3,601	3,432
8	Hospital 7	3,736	3,370	3,256	3,458	3,528	3,528	3,735	3,379	3,749	3,445	3,254	3,331	3,611	3,516	3,301	3,734
9	Hospital 8	3,520	3,644	3,331	3,741	3,281	3,281	3,560	3,283	3,714	3,667	3,597	3,338	3,681	3,700	3,328	3,657
10	Hospital 9	3,318	3,707	3,334	3,461	3,676	3,676	3,317	3,278	3,573	3,528	3,281	3,412	3,357	3,330	3,707	3,332
11	Hospital 10	3,360	3,738	3,765	3,289	3,758	3,758	3,295	3,425	3,405	3,300	3,458	3,358	3,422	3,593	3,699	3,295
12	Hospital 11	3,750	3,710	3,606	3,456	3,545	3,545	3,304	3,720	3,300	3,646	3,273	3,590	3,496	3,731	3,407	3,388
13	Hospital 12	3,622	3,638	3,569	3,685	3,410	3,410	3,440	3,657	3,561	3,328	3,378	3,561	3,374	3,328	3,655	3,704
14	Hospital 13	3,288	3,764	3,696	3,430	3,734	3,734	3,391	3,695	3,567	3,533	3,596	3,712	3,468	3,507	3,643	3,446
15	Hospital 14	3,311	3,564	3,482	3,597	3,698	3,698	3,419	3,478	3,413	3,453	3,349	3,281	3,485	3,537	3,384	3,755
16	Hospital 15	3,382	3,641	3,380	3,477	3,384	3,384	3,698	3,542	3,685	3,425	3,284	3,768	3,356	3,612	3,767	3,391
17	Hospital 16	3,755	3,364	3,566	3,737	3,490	3,490	3,356	3,386	3,588	3,335	3,483	3,526	3,316	3,710	3,585	3,309
18	Hospital 17	3,626	3,371	3,737	3,662	3,631	3,631	3,485	3,281	3,415	3,532	3,286	3,436	3,772	3,542	3,504	3,405
19	Hospital 18	3,399	3,332	3,376	3,740	3,366	3,366	3,323	3,561	3,453	3,761	3,649	3,691	3,514	3,386	3,456	3,671
20	Hospital 19	3,322	3,308	3,309	3,474	3,530	3,530	3,725	3,483	3,308	3,711	3,278	3,679	3,633	3,431	3,565	3,581
21	Hospital 20	3,610	3,536	3,548	3,683	3,292	3,292	3,561	3,643	3,511	3,423	3,726	3,590	3,394	3,724	3,345	3,633
22	Hospital 21	3,587	3,714	3,271	3,758	3,562	3,562	3,774	3,421	3,586	3,444	3,353	3,313	3,498	3,397	3,599	3,341
23	Hospital 22	3,356	3,465	3,747	3,555	3,262	3,262	3,366	3,600	3,635	3,315	3,259	3,574	3,373	3,497	3,412	3,281
24	Hospital 23	3,369	3,538	3,432	3,367	3,709	3,709	3,281	3,529	3,512	3,464	3,492	3,311	3,392	3,667	3,281	3,597
25	Hospital 24	3,555	3,401	3,535	3,427	3,461	3,461	3,605	3,717	3,525	3,535	3,499	3,656	3,418	3,589	3,696	3,750
26	Hospital 25	3,341	3,619	3,503	3,379	3,330	3,330	3,392	3,486	3,459	3,529	3,310	3,438	3,680	3,748	3,649	3,298
27	Hospital 26	3,722	3,361	3,577	3,383	3,314	3,314	3,760	3,549	3,590	3,737	3,526	3,407	3,677	3,681	3,580	3,711
28	Hospital 27	3,399	3,250	3,310	3,291	3,569	3,569	3,753	3,329	3,651	3,300	3,774	3,526	3,302	3,615	3,677	3,349
29	Hospital 28	3,703	3,561	3,463	3,384	3,493	3,493	3,266	3,348	3,747	3,295	3,495	3,435	3,337	3,254	3,709	3,356
30	Hospital 29	3,613	3,547	3,494	3,336	3,585	3,585	3,298	3,682	3,464	3,294	3,651	3,734	3,685	3,482	3,287	3,495
31	Hospital 30	3,496	3,418	3,313	3,629	3,492	3,492	3,751	3,544	3,587	3,305	3,294	3,457	3,539	3,512	3,397	3,756
32	Hospital 31	3,505	3,603	3,616	3,367	3,703	3,703	3,547	3,322	3,774	3,470	3,719	3,262	3,497	3,396	3,755	3,772
33	Hospital 32	3,459	3,508	3,306	3,435	3,596	3,596	3,335	3,432	3,478	3,501	3,447	3,344	3,414	3,422	3,362	3,487
34	Hospital 33	3,343	3,732	3,277	3,710	3,341	3,341	3,712	3,579	3,732	3,360	3,368	3,771	3,339	3,710	3,767	3,646
35	Hospital 34	3,485	3,620	3,547	3,338	3,715	3,715	3,384	3,371	3,400	3,595	3,371	3,381	3,725	3,594	3,352	3,763

APPENDIX 4

A snapshot of per day revenue (PdR) from hospital stay data of 35 out of 79 hospitals

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Hospital	Appendix removal	Caesarean delivery	Cellulitis	Chronic obstructive pulmonary disease (with complications)	Chronic obstructive pulmonary disease (without complications)	Gallbladder removal	Gynaecological reconstructive procedures	Heart failure (with complications)	Heart failure (without complications)	Hip replacement	Hysterectomy	Kidney and urinary tract infections (with complications)	Kidney and urinary tract infections (without complications)	Knee replacement	Prostate removal	Vaginal delivery
2	Hospital 1	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
3	Hospital 2	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
4	Hospital 3	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
5	Hospital 4	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
6	Hospital 5	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
7	Hospital 6	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
8	Hospital 7	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
9	Hospital 8	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
10	Hospital 9	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
11	Hospital 10	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
12	Hospital 11	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
13	Hospital 12	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
14	Hospital 13	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
15	Hospital 14	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
16	Hospital 15	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
17	Hospital 16	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
18	Hospital 17	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
19	Hospital 18	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
20	Hospital 19	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
21	Hospital 20	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
22	Hospital 21	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
23	Hospital 22	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
24	Hospital 23	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
25	Hospital 24	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
26	Hospital 25	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
27	Hospital 26	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
28	Hospital 27	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
29	Hospital 28	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
30	Hospital 29	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
31	Hospital 30	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
32	Hospital 31	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
33	Hospital 32	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
34	Hospital 33	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200
35	Hospital 34	4,200	4,250	4,550	4,655	4,250	4,650	4,800	4,850	4,750	4,500	4,600	4,750	4,550	4,500	4,150	4,200

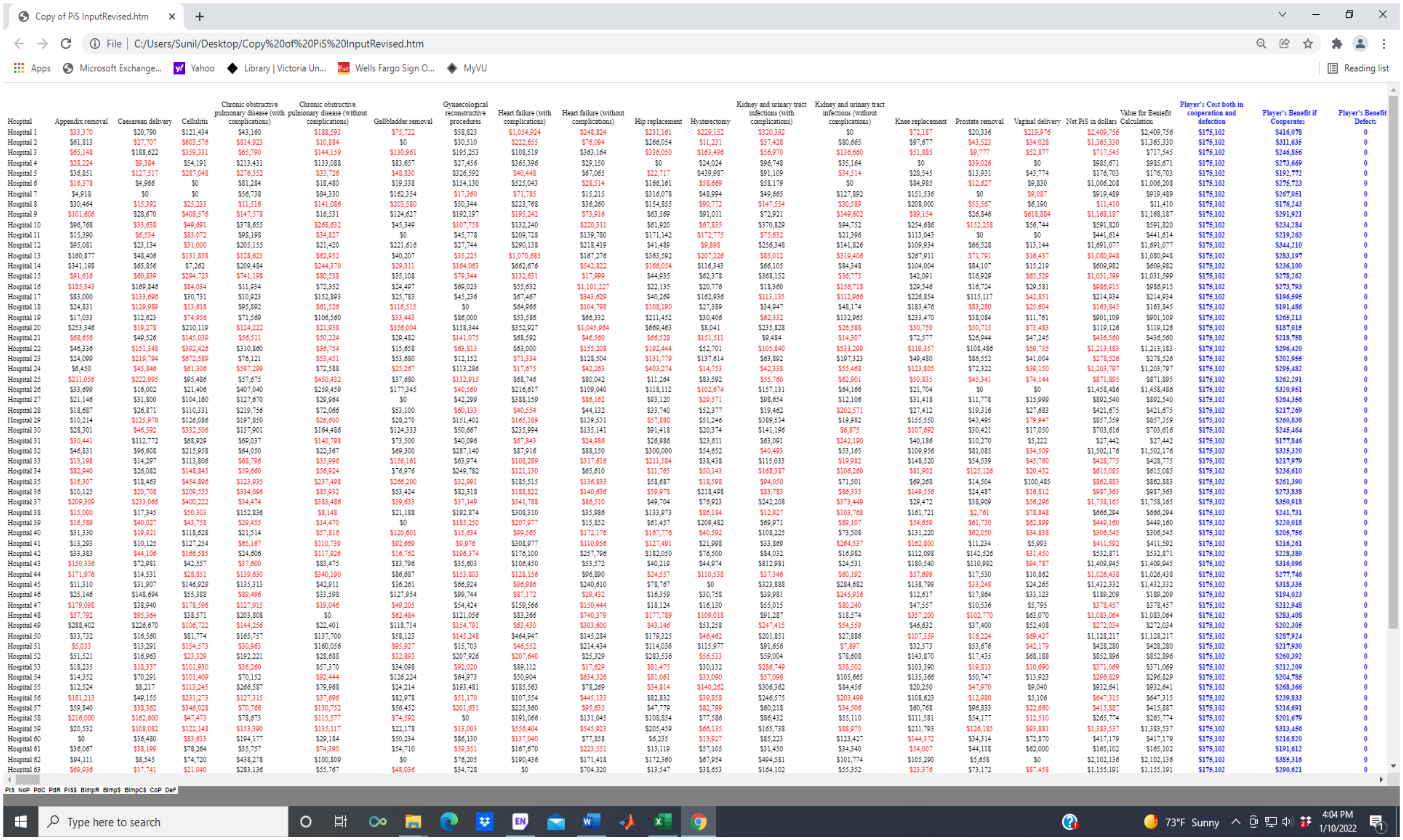
APPENDIX 5

A snapshot of dollar value of the policy implementation status (PiS$) of 35 out of 79 hospitals

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Hospital	Appendix removal	Caesarean delivery	Cellulitis	Chronic obstructive pulmonary disease (with complications)	Chronic obstructive pulmonary disease (without complications)	Gallbladder removal	Gynaecological reconstructive procedures	Heart failure (with complications)	Heart failure (without complications)	Hip replacement	Hysterectomy	Kidney and urinary tract infections (with complications)	Kidney and urinary tract infections (without complications)	Knee replacement	Prostate removal	Vaginal delivery	Net PiS in dollars
2	Hospital 1	$33,370	$20,790	$121,434	$43,160	$188,593	$75,722	$58,823	$1,054,924	$248,824	$231,161	$229,152	$320,392	$0	$72,187	$20,336	$219,976	$2,409,756
3	Hospital 2	$61,813	$27,707	$603,576	$814,923	$10,884	$0	$30,510	$222,655	$76,094	$266,054	$11,231	$57,428	$80,665	$97,677	$43,523	$34,028	$1,365,330
4	Hospital 3	$65,148	$188,622	$359,331	$65,790	$144,159	$130,961	$195,253	$108,519	$363,164	$336,050	$163,496	$56,970	$136,660	$51,885	$9,777	$52,877	$717,545
5	Hospital 4	$28,224	$9,384	$54,191	$213,431	$133,088	$83,657	$27,456	$365,396	$29,150	$0	$24,024	$96,748	$35,164	$0	$39,026	$0	$985,671
6	Hospital 5	$36,851	$127,517	$287,048	$276,352	$33,726	$48,830	$326,592	$40,448	$67,065	$22,717	$439,987	$91,109	$34,514	$28,545	$13,931	$43,774	$176,703
7	Hospital 6	$16,378	$4,966	$0	$81,284	$18,480	$19,338	$154,130	$525,043	$28,514	$166,161	$58,669	$58,179	$0	$84,985	$12,627	$9,830	$1,006,208
8	Hospital 7	$4,918	$0	$0	$56,738	$84,330	$162,354	$17,360	$71,785	$15,215	$316,078	$48,994	$49,665	$127,892	$151,536	$0	$9,087	$919,489
9	Hospital 8	$30,464	$15,392	$25,233	$11,516	$141,086	$203,580	$50,344	$223,768	$36,260	$154,855	$90,772	$147,554	$30,589	$208,000	$55,567	$6,190	$11,410
10	Hospital 9	$101,606	$28,670	$408,576	$147,578	$16,531	$124,627	$192,197	$195,242	$73,916	$63,569	$91,011	$72,921	$149,602	$89,154	$26,846	$618,884	$1,168,187
11	Hospital 10	$96,768	$33,638	$49,691	$378,655	$268,632	$45,349	$107,758	$132,240	$220,311	$61,920	$67,835	$370,829	$94,752	$254,686	$152,258	$56,744	$591,820
12	Hospital 11	$15,390	$6,534	$83,072	$98,198	$34,827	$0	$45,778	$209,728	$139,780	$171,142	$172,775	$75,632	$21,396	$113,043	$0	$0	$441,614
13	Hospital 12	$95,081	$23,134	$31,000	$205,155	$21,420	$221,616	$27,744	$290,138	$218,419	$41,489	$9,898	$256,348	$141,826	$109,934	$66,528	$13,144	$1,691,077
14	Hospital 13	$160,877	$48,406	$131,858	$128,625	$62,952	$40,207	$35,225	$1,070,685	$167,276	$363,592	$207,226	$85,012	$319,406	$267,911	$71,791	$16,437	$1,080,948
15	Hospital 14	$341,198	$65,856	$7,262	$209,484	$244,370	$29,311	$164,063	$662,676	$542,822	$166,054	$116,343	$66,105	$84,348	$104,004	$84,107	$15,219	$609,982
16	Hospital 15	$91,616	$60,839	$294,723	$741,198	$80,538	$35,108	$79,344	$132,631	$17,999	$44,935	$62,378	$368,152	$36,775	$42,091	$16,929	$65,529	$1,031,599
17	Hospital 16	$185,343	$169,846	$84,034	$11,934	$72,352	$24,497	$69,023	$55,632	$1,101,227	$22,135	$20,776	$18,360	$156,718	$29,546	$16,724	$29,581	$986,915
18	Hospital 17	$83,000	$133,696	$30,731	$10,923	$152,893	$25,783	$45,236	$67,467	$343,629	$40,269	$162,936	$113,135	$112,966	$226,854	$115,117	$42,851	$214,934
19	Hospital 18	$24,831	$129,989	$13,618	$95,892	$61,526	$116,515	$0	$64,966	$104,798	$108,190	$27,389	$34,947	$48,174	$183,476	$83,280	$25,604	$163,845
20	Hospital 19	$17,033	$12,623	$74,956	$71,569	$106,560	$33,443	$86,000	$53,586	$66,332	$211,452	$30,406	$62,332	$132,965	$233,470	$38,084	$11,761	$901,109
21	Hospital 20	$253,346	$19,278	$210,119	$124,222	$21,938	$356,004	$158,344	$352,927	$1,045,964	$669,463	$8,041	$235,828	$26,588	$50,750	$50,715	$73,483	$119,126
22	Hospital 21	$68,656	$49,526	$145,039	$56,511	$50,224	$29,482	$141,075	$68,592	$46,560	$66,528	$151,511	$9,484	$14,307	$72,577	$26,944	$47,245	$436,560
23	Hospital 22	$46,336	$151,348	$392,426	$310,860	$36,754	$15,658	$63,813	$63,000	$155,208	$192,444	$52,701	$105,840	$533,299	$119,357	$108,486	$59,735	$1,213,183
24	Hospital 23	$24,099	$219,794	$672,589	$76,121	$53,451	$53,680	$12,152	$71,334	$128,504	$131,779	$137,614	$63,892	$197,323	$49,480	$86,552	$41,004	$278,526
25	Hospital 24	$6,450	$45,846	$61,306	$597,299	$72,588	$25,267	$113,286	$17,675	$42,263	$403,274	$14,753	$42,338	$55,468	$123,805	$72,322	$39,150	$1,203,797
26	Hospital 25	$211,056	$222,995	$95,486	$57,675	$450,432	$37,680	$132,915	$68,746	$80,042	$11,264	$83,592	$55,760	$62,901	$50,835	$45,341	$74,144	$871,895
27	Hospital 26	$33,699	$16,002	$21,406	$407,040	$259,459	$177,345	$40,560	$216,617	$109,040	$118,112	$102,674	$157,131	$64,166	$21,704	$0	$0	$1,458,486
28	Hospital 27	$21,146	$31,800	$104,160	$127,670	$29,964	$0	$42,299	$388,159	$86,162	$93,120	$29,571	$98,654	$12,106	$31,418	$11,778	$15,999	$892,540
29	Hospital 28	$18,687	$26,871	$110,331	$219,756	$72,066	$53,100	$60,133	$40,554	$44,132	$33,740	$52,377	$19,462	$202,571	$27,412	$19,316	$27,683	$421,675
30	Hospital 29	$10,214	$125,978	$126,086	$197,850	$26,600	$28,270	$151,402	$165,389	$139,531	$57,888	$51,246	$389,534	$19,982	$155,550	$43,495	$79,947	$857,359
31	Hospital 30	$28,301	$46,592	$332,506	$157,901	$164,486	$124,333	$50,667	$235,994	$135,141	$91,418	$20,374	$141,196	$6,875	$107,692	$30,421	$17,050	$703,616
32	Hospital 31	$30,441	$112,772	$68,929	$69,037	$140,798	$73,500	$40,096	$67,843	$24,986	$26,986	$23,611	$63,091	$242,190	$40,186	$10,270	$5,222	$27,442
33	Hospital 32	$46,831	$96,608	$215,958	$64,050	$22,367	$69,300	$287,140	$87,916	$88,150	$300,000	$54,652	$40,493	$53,165	$109,956	$81,085	$34,509	$1,502,176
34	Hospital 33	$13,198	$14,297	$113,806	$68,796	$35,996	$156,161	$63,974	$108,289	$317,616	$211,584	$38,438	$115,033	$19,982	$148,520	$54,539	$45,760	$428,775
35	Hospital 34	$82,940	$26,082	$148,845	$59,660	$56,924	$76,976	$249,782	$121,130	$65,610	$11,765	$50,143	$168,387	$106,260	$81,902	$125,126	$20,452	$615,085

APPENDIX 6

A snapshot of the data used in the social network model



Hospital	Appendix removal	Caesarean delivery	Cellulitis	Chronic obstructive pulmonary disease (with complications)	Chronic obstructive pulmonary disease (without complications)	Gallbladder removal	Gynaecological reconstructive procedures	Heart failure (with complications)	Heart failure (without complications)	Hip replacement	Hysterectomy	Kidney and urinary tract infections (with complications)	Kidney and urinary tract infections (without complications)	Knee replacement	Prostate removal	Vaginal delivery	Net PiS in dollars	Value for Beniefit Calculation	Player's Cost both in cooperation and defection	Player's Benefit if Cooperates	Player's Benefit Defects
Hospital 1	$33,370	$20,790	$121,434	$43,160	$188,593	$75,722	$58,823	$1,054,924	$248,824	$231,161	$229,152	$320,392	$0	$72,187	$20,336	$219,976	$2,409,756	$2,409,756	$175,102	$416,078	0
Hospital 2	$61,813	$27,707	$603,576	$814,923	$10,884	$0	$30,510	$222,655	$76,094	$266,054	$11,231	$57,428	$80,665	$97,677	$43,523	$34,028	$1,365,330	$1,365,330	$175,102	$311,636	0
Hospital 3	$65,148	$188,622	$359,331	$65,790	$144,159	$130,961	$195,253	$108,519	$363,164	$336,050	$163,496	$56,970	$136,660	$51,885	$9,777	$52,877	$717,545	$717,545	$175,102	$246,856	0
Hospital 4	$28,224	$9,384	$54,191	$213,431	$133,088	$83,657	$27,456	$365,396	$29,150	$0	$24,024	$96,748	$35,164	$0	$39,026	$0	$985,671	$985,671	$175,102	$273,669	0
Hospital 5	$36,851	$127,517	$287,048	$276,352	$33,726	$48,830	$326,592	$40,448	$67,065	$22,717	$439,987	$91,109	$34,514	$28,545	$13,931	$43,774	$176,703	$176,703	$175,102	$192,772	0
Hospital 6	$16,378	$4,966	$0	$81,284	$18,480	$19,338	$154,130	$525,043	$28,514	$166,161	$58,669	$58,179	$0	$84,985	$12,627	$9,830	$1,006,208	$1,006,208	$175,102	$275,723	0
Hospital 7	$4,918	$0	$0	$56,738	$84,330	$162,354	$17,360	$71,785	$15,215	$316,078	$48,994	$49,665	$127,892	$151,536	$0	$9,087	$919,489	$919,489	$175,102	$267,051	0
Hospital 8	$30,464	$15,392	$25,233	$11,516	$141,086	$203,580	$50,344	$223,768	$36,260	$154,855	$90,772	$147,554	$30,589	$208,000	$55,567	$6,190	$11,410	$11,410	$175,102	$176,243	0
Hospital 9	$101,606	$28,670	$408,576	$147,578	$16,531	$124,627	$192,197	$195,242	$73,916	$63,569	$91,011	$72,921	$149,602	$89,154	$26,846	$618,884	$1,168,187	$1,168,187	$175,102	$291,921	0
Hospital 10	$96,768	$33,638	$49,691	$378,655	$268,632	$45,349	$107,758	$132,240	$220,311	$61,920	$67,835	$370,829	$94,752	$254,686	$152,258	$56,744	$591,820	$591,820	$175,102	$234,284	0
Hospital 11	$15,390	$6,534	$83,072	$98,198	$34,827	$0	$45,778	$209,728	$139,780	$171,142	$172,775	$75,632	$21,396	$113,043	$0	$0	$441,614	$441,614	$175,102	$219,263	0
Hospital 12	$95,081	$23,134	$31,000	$205,155	$21,420	$221,616	$27,744	$290,138	$218,419	$41,489	$9,898	$256,348	$141,826	$109,934	$66,528	$13,144	$1,691,077	$1,691,077	$175,102	$344,210	0
Hospital 13	$160,877	$48,406	$131,858	$128,625	$62,952	$40,207	$35,225	$1,070,685	$167,276	$363,592	$207,226	$85,012	$319,406	$267,911	$71,791	$16,437	$1,080,948	$1,080,948	$175,102	$283,197	0
Hospital 14	$341,198	$65,856	$7,262	$209,484	$244,370	$29,311	$164,063	$662,676	$542,822	$166,054	$116,343	$66,105	$84,348	$104,004	$84,107	$15,219	$609,982	$609,982	$175,102	$236,100	0
Hospital 15	$91,616	$60,839	$294,723	$741,198	$80,538	$35,108	$79,344	$132,631	$17,999	$44,935	$62,378	$368,152	$36,775	$42,091	$16,929	$65,529	$1,031,599	$1,031,599	$175,102	$278,262	0
Hospital 16	$185,343	$169,846	$84,034	$11,934	$72,352	$24,497	$69,023	$55,632	$1,101,227	$22,135	$20,776	$18,360	$156,718	$29,546	$16,724	$29,581	$986,915	$986,915	$175,102	$273,793	0
Hospital 17	$83,000	$133,696	$30,731	$10,923	$152,893	$25,783	$45,236	$67,467	$343,629	$40,269	$162,936	$113,135	$112,966	$226,854	$115,117	$42,851	$214,934	$214,934	$175,102	$196,595	0
Hospital 18	$24,831	$129,989	$13,618	$95,892	$61,526	$116,515	$0	$64,966	$104,798	$108,190	$27,389	$34,947	$48,174	$183,476	$83,280	$25,604	$163,845	$163,845	$175,102	$191,486	0
Hospital 19	$17,033	$12,623	$74,956	$71,569	$106,560	$33,443	$86,000	$53,586	$66,332	$211,452	$30,406	$62,332	$132,965	$233,470	$38,084	$11,761	$901,109	$901,109	$175,102	$265,213	0
Hospital 20	$253,346	$19,278	$210,119	$124,222	$21,938	$356,004	$158,344	$352,927	$1,045,964	$669,463	$8,041	$235,828	$26,588	$50,750	$50,715	$73,483	$119,126	$119,126	$175,102	$187,015	0
Hospital 21	$68,656	$49,526	$145,039	$56,511	$50,224	$29,482	$141,075	$68,592	$46,560	$66,528	$151,511	$9,484	$14,307	$72,577	$26,944	$47,245	$436,560	$436,560	$175,102	$218,758	0
Hospital 22	$46,336	$151,348	$392,426	$310,860	$36,754	$15,658	$63,813	$63,000	$155,208	$192,444	$52,701	$105,840	$533,299	$119,357	$108,486	$59,735	$1,213,183	$1,213,183	$175,102	$296,420	0
Hospital 23	$24,099	$219,794	$672,589	$76,121	$53,451	$53,680	$12,152	$71,334	$128,504	$131,779	$137,614	$63,892	$197,323	$49,480	$86,552	$41,004	$278,526	$278,526	$175,102	$202,955	0
Hospital 24	$6,450	$45,846	$61,306	$597,299	$72,588	$25,267	$113,286	$17,675	$42,263	$403,274	$14,753	$42,338	$55,468	$123,805	$72,322	$39,150	$1,203,797	$1,203,797	$175,102	$295,482	0
Hospital 25	$211,056	$222,995	$95,486	$57,675	$450,432	$37,680	$132,915	$68,746	$80,042	$11,264	$83,592	$55,760	$62,901	$50,835	$45,341	$74,144	$871,895	$871,895	$175,102	$262,291	0
Hospital 26	$33,699	$16,002	$21,406	$407,040	$259,459	$177,345	$40,560	$216,617	$109,040	$118,112	$102,674	$157,131	$64,166	$21,704	$0	$0	$1,458,486	$1,458,486	$175,102	$320,951	0
Hospital 27	$21,146	$31,800	$104,160	$127,670	$29,964	$0	$42,299	$388,159	$86,162	$93,120	$29,571	$98,654	$12,106	$31,418	$11,778	$15,999	$892,540	$892,540	$175,102	$264,356	0
Hospital 28	$18,687	$26,871	$110,331	$219,756	$72,066	$53,100	$60,133	$40,554	$44,132	$33,740	$52,377	$19,462	$202,571	$27,412	$19,316	$27,683	$421,675	$421,675	$175,102	$217,269	0
Hospital 29	$10,214	$125,978	$126,086	$197,850	$26,600	$28,270	$151,402	$165,389	$139,531	$57,888	$51,246	$389,534	$19,982	$155,550	$43,495	$79,947	$857,359	$857,359	$175,102	$260,838	0
Hospital 30	$28,301	$46,592	$332,506	$157,901	$164,486	$124,333	$50,667	$235,994	$135,141	$91,418	$20,374	$141,196	$6,875	$107,692	$30,421	$17,050	$703,616	$703,616	$175,102	$245,464	0
Hospital 31	$30,441	$112,772	$68,929	$69,037	$140,798	$73,500	$40,096	$67,843	$24,986	$26,986	$23,611	$63,091	$242,190	$40,186	$10,270	$5,222	$27,442	$27,442	$175,102	$177,846	0
Hospital 32	$46,831	$96,608	$215,958	$64,050	$22,367	$69,300	$287,140	$87,916	$88,150	$300,000	$54,652	$40,493	$53,165	$109,956	$81,085	$34,509	$1,502,176	$1,502,176	$175,102	$325,320	0
Hospital 33	$13,198	$14,297	$113,806	$68,796	$35,996	$156,161	$63,974	$108,289	$317,616	$211,584	$38,438	$115,033	$19,982	$148,520	$54,539	$45,760	$428,775	$428,775	$175,102	$217,979	0
Hospital 34	$82,940	$26,082	$148,845	$59,660	$56,924	$76,976	$249,782	$121,130	$65,610	$11,765	$50,143	$168,387	$106,260	$81,902	$125,126	$20,452	$615,085	$615,085	$175,102	$236,610	0
Hospital 35	$16,307	$18,463	$454,896	$123,935	$237,498	$266,200	$32,991	$185,515	$136,833	$58,687	$18,598	$94,050	$71,501	$69,268	$14,504	$100,485	$862,883	$862,883	$175,102	$261,390	0
Hospital 36	$10,125	$20,708	$209,555	$334,096	$85,932	$53,424	$82,318	$188,822	$140,636	$59,978	$218,498	$83,783	$86,335	$149,556	$24,487	$16,812	$987,363	$987,363	$175,102	$273,838	0
Hospital 37	$209,309	$233,066	$400,222	$34,474	$383,486	$39,633	$37,149	$341,788	$86,510	$49,704	$76,923	$242,208	$373,449	$29,472	$38,909	$56,296	$1,758,165	$1,758,165	$175,102	$350,918	0
Hospital 38	$15,000	$17,345	$50,303	$152,836	$8,148	$21,188	$192,874	$308,310	$35,986	$133,973	$86,184	$12,927	$103,768	$161,721	$2,761	$78,848	$666,294	$666,294	$175,102	$241,731	0
Hospital 39	$16,589	$40,027	$43,758	$29,455	$14,470	$0	$185,250	$207,977	$15,852	$61,457	$209,482	$69,971	$89,107	$54,659	$61,730	$62,899	$449,160	$449,160	$175,102	$220,018	0
Hospital 40	$31,330	$19,921	$118,628	$21,514	$57,816	$120,601	$15,634	$99,565	$172,176	$167,776	$40,592	$108,225	$73,508	$131,220	$62,050	$34,838	$306,545	$306,545	$175,102	$205,756	0
Hospital 41	$13,293	$10,125	$127,254	$65,167	$110,739	$92,669	$9,976	$308,977	$110,956	$127,491	$21,998	$33,869	$264,537	$162,800	$11,234	$5,993	$411,592	$411,592	$175,102	$216,261	0
Hospital 42	$33,383	$44,106	$166,585	$24,606	$117,926	$16,762	$196,374	$176,100	$257,796	$182,050	$76,500	$84,032	$16,982	$112,098	$142,526	$31,450	$532,871	$532,871	$175,102	$228,389	0
Hospital 43	$150,336	$72,981	$42,557	$37,600	$83,475	$83,796	$35,603	$106,450	$53,572	$40,219	$44,974	$812,981	$24,531	$180,540	$110,992	$94,787	$1,409,945	$1,409,945	$175,102	$316,096	0
Hospital 44	$171,976	$14,531	$28,851	$139,630	$340,190	$86,687	$153,803	$128,156	$96,890	$24,557	$110,538	$37,346	$60,192	$57,699	$17,530	$10,862	$1,026,438	$1,026,438	$175,102	$277,746	0
Hospital 45	$11,310	$31,907	$146,929	$135,313	$42,911	$36,261	$66,924	$96,986	$240,610	$78,767	$0	$323,888	$284,682	$138,799	$33,248	$24,265	$1,432,332	$1,432,332	$175,102	$318,335	0
Hospital 46	$25,146	$148,694	$55,388	$89,496	$33,598	$127,954	$99,744	$87,172	$29,432	$16,359	$30,758	$39,981	$245,916	$12,617	$17,864	$33,123	$189,209	$189,209	$175,102	$194,023	0
Hospital 47	$179,098	$38,940	$178,596	$127,915	$19,046	$49,205	$54,424	$159,566	$150,444	$18,124	$16,130	$55,015	$80,240	$47,557	$10,536	$5,795	$378,457	$378,457	$175,102	$212,948	0
Hospital 48	$57,792	$95,364	$38,571	$203,808	$0	$62,484	$121,056	$83,366	$740,379	$177,789	$109,018	$91,287	$18,574	$357,200	$102,770	$63,070	$1,083,064	$1,083,064	$175,102	$283,408	0
Hospital 49	$288,402	$226,670	$106,722	$144,256	$22,401	$118,714	$154,791	$63,430	$303,600	$43,146	$53,258	$247,415	$54,559	$46,632	$37,400	$52,408	$272,034	$272,034	$175,102	$202,305	0
Hospital 50	$33,732	$16,560	$81,774	$165,757	$137,700	$58,123	$145,248	$464,947	$145,284	$179,325	$46,462	$201,851	$27,886	$107,359	$16,224	$69,427	$1,128,217	$1,128,217	$175,102	$287,924	0
Hospital 51	$5,033	$13,291	$154,573	$30,963	$160,056	$95,927	$15,703	$46,552	$214,434	$114,036	$115,977	$91,656	$7,897	$32,573	$53,676	$42,179	$428,280	$428,280	$175,102	$217,930	0
Hospital 52	$51,521	$16,963	$23,329	$192,221	$28,688	$32,893	$207,926	$207,640	$25,329	$283,536	$56,533	$59,004	$78,608	$143,870	$17,435	$68,188	$852,896	$852,896	$175,102	$260,392	0
Hospital 53	$18,235	$18,337	$101,930	$36,260	$57,370	$34,098	$92,020	$89,112	$17,629	$81,475	$30,132	$286,749	$38,502	$103,390	$19,813	$10,690	$371,069	$371,069	$175,102	$212,209	0
Hospital 54	$14,352	$70,291	$101,409	$70,152	$92,444	$126,224	$64,973	$50,904	$634,326	$81,061	$33,090	$57,096	$105,665	$135,366	$50,747	$13,923	$296,829	$296,829	$175,102	$204,785	0
Hospital 55	$12,524	$8,217	$113,245	$266,587	$79,968	$24,214	$193,481	$185,563	$78,269	$34,814	$140,262	$306,362	$84,456	$20,250	$47,970	$9,040	$932,641	$932,641	$175,102	$268,366	0
Hospital 56	$181,213	$49,155	$231,273	$127,315	$37,696	$82,978	$51,170	$107,554	$445,133	$82,832	$39,858	$246,575	$203,499	$108,623	$12,980	$5,106	$647,315	$647,315	$175,102	$239,833	0
Hospital 57	$59,840	$38,362	$346,028	$70,766	$130,752	$56,452	$201,631	$225,360	$95,635	$47,779	$82,799	$60,218	$34,506	$60,768	$96,833	$22,660	$415,887	$415,887	$175,102	$216,691	0
Hospital 58	$216,000	$162,600	$47,473	$78,673	$115,577	$74,592	$0	$191,066	$131,045	$108,854	$77,586	$86,432	$55,110	$111,581	$54,177	$12,510	$265,774	$265,774	$175,102	$201,679	0
Hospital 59	$20,532	$108,082	$122,148	$153,390	$135,117	$22,178	$13,003	$556,404	$545,923	$205,459	$66,135	$165,738	$88,970	$211,793	$126,185	$93,881	$1,383,537	$1,383,537	$175,102	$313,456	0
Hospital 60	$0	$36,480	$83,613	$194,177	$29,184	$50,234	$86,130	$137,040	$77,858	$6,235	$13,927	$85,223	$123,427	$144,372	$34,314	$72,870	$417,179	$417,179	$175,102	$216,820	0
Hospital 61	$36,067	$38,199	$78,264	$35,757	$74,390	$54,710	$59,351	$167,670	$223,551	$13,119	$57,105	$31,450	$34,340	$54,007	$44,118	$62,000	$165,102	$165,102	$175,102	$191,612	0
Hospital 62	$94,111	$8,545	$74,720	$438,278	$100,809	$0	$76,205	$190,436	$171,418	$172,360	$67,954	$494,581	$101,774	$105,290	$5,658	$0	$2,102,136	$2,102,136	$175,102	$385,316	0
Hospital 63	$69,936	$17,741	$21,040	$283,136	$55,767	$48,036	$34,728	$0	$704,320	$13,547	$38,653	$164,102	$55,352	$23,376	$73,172	$87,458	$1,155,191	$1,155,191	$175,102	$290,621	0