Intégration entre services hospitaliers : management des opérations en cancérologie

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INTEGRATING HOSPITAL DEPARTMENTS: AN OPERATIONS MANAGEMENT APPROACH FOR CANCER CARE

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À mes parents.

Vivre. […] J'aime ce métier. Malgré la violence et la vulgarité de ces « sombres temps », le principe vital est plus ardent que jamais. Le métier de vivre est pourtant pénible. On s'y éreinte. C'est souvent répétitif. Mais pour rien au monde je ne renoncerais au charme douloureux de ma condition d'homme.

Jean-Paul Kauffmann, *La maison du retour*, 2007

Je suis allé à Koumassi sans but précis. En général, on considère qu'avoir un objectif, c'est positif car cela motive. D'un autre côté, quand on a un but, on a des œillères : on a en vue son objectif et rien d'autre. Or ce qu'il y a autour, dans un horizon plus large, un champ plus profond est souvent bien plus intéressant et important. Aborder un univers, c'est pénétrer un mystère pouvant receler une infinité de labyrinthes, de recoins, d'énigmes et d'inconnues !

Ryszard Kapuściński, *Ébène,* 1998

« Quoi que je fasse, je ne puis que m'enfoncer plus avant dans une vie qui est finalement la mienne, mais avec laquelle je ne coïncide pas. Et, en vous rencontrant, je me suis demandé si vous, enfin, vous ne déteniez pas le secret.

- *Quel secret ?*
- *Celui de l'errance dont nous découvrons tous, dès lors que nous avons commencé à réaliser quelque chose, qu'elle était notre aspiration la plus profonde et la plus tenace. »*

Jacques Abeille, *Les Jardins statuaires,* 1982

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List of Abbreviations

AR	Action Research
DES	Discrete Event Simulation
DS	Design Science
HSR	Health Services Research
IS	Information System
M&S	Modelling & Simulation
OM	Operations Management
OR	Operations Research
PAMC	Public Academic Medical Center
PSM	Problem Structuring Method
SB	Service Blueprinting
SD	System Dynamics
SE	Systems Engineering
SSM	Soft Systems Methodology
VSM	Viable System Model

Contents

ACKNOWLEDGEMENTS - REMERCIEMENTS .... **VII**

LIST OF ABBREVIATIONS .... **IX**

CONTENTS .... **XI**

LIST OF TABLES .... **XIII**

LIST OF FIGURES .... **XIII**

RESUME .... **XV**

ABSTRACT .... **XIX**

INTRODUCTION **1**

1. General Context 3
2. Context of this Work 6
3. Research Questions 8
4. Related Research Fields 9
5. Related Methodological Approaches 16
6. Our Approach 28
7. Structure of the Manuscript 29

I. OUTPATIENT CHEMOTHERAPY: A LITERATURE REVIEW WITH INSIGHTS FROM A CASE STUDY **33**

1. Introduction 35
2. Literature Review Procedure 36
3. Background: Introduction to Outpatient Chemotherapy 36
4. Management of Chemotherapy Production and Administration 39
5. Specific Complexities when Modelling Outpatient Chemotherapy Planning 44
6. The View from Practice: Outpatient Chemotherapy in a French Public General Hospital 47
7. Discussion: Opportunities for Future Research 49
8. Conclusion 51

II. MULTIDEPARTMENT INTEGRATION: A MULTIMETHODOLOGY TO INITIATE A CHANGE PROGRAM IN A HOSPITAL'S CANCER DIVISION **53**

1. Introduction 55
2. Literature Review 56
3. Setting and Methodology 60
4. Results 62
5. Discussion 67
6. Conclusion 70

III. INTER-DEPARTMENT COORDINATION TO IMPROVE PATIENT FLOWS IN HOSPITALS ... 73
1. Introduction ... 75
2. Theoretical Background ... 75
3. Problem Description ... 78
4. Proposed Methodology ... 79
5. Narrative of the Case Study ... 83
6. Discussion ... 89
7. Conclusion ... 92
IV. A SYSTEMS APPROACH TO THE CHALLENGES OF STRATEGIC PLANNING ACADEMIC MEDICAL CENTERS ... 93
1. Introduction ... 95
2. Literature Review ... 95
3. Materials and Methods ... 98
4. Results ... 100
5. Discussion ... 105
6. Conclusion ... 109
CONCLUSION ... 111
1. General Discussion ... 113
2. Theoretical Contributions ... 116
3. Managerial Implications ... 117
4. Limitations and Further Research ... 118
APPENDIX A. DETAILS ON THE SIMULATION MODEL IN CHAPTER III ... 121
APPENDIX B. DETAILS ON THE STRUCTURAL ANALYSIS IN CHAPTER IV ... 125
REFERENCES ... 129
PERSONAL PUBLICATIONS ... 153

List of Tables

TABLE 1 - TYPES OF MODELS USED IN HEALTHCARE M&S (BRAILSFORD, HARPER, ET AL., 2009) 26
TABLE 2 - TOOLS FOR HEALTHCARE MODELLING AND SIMULATION (JUN ET AL., 2011)........ 27
TABLE 3 - OPTIONS FOR OUTPATIENT CHEMOTHERAPY DELIVERY........ 39
TABLE 5 - OUTPATIENT CHEMOTHERAPY PLANNING DECISIONS........ 41
TABLE 6 - THE FOUR METHODS COMBINED IN OUR APPROACH........ 82
TABLE 6 - SOLUTION CONCEPTS IDENTIFIED IN THE BENCHMARK 86
TABLE 7 - RESEARCH FRAMEWORK 99
TABLE 8 - DISTRIBUTIONS FOR SERVICE TIMES IN THE DES MODEL 121

List of Figures

FIGURE 1 - HEALTHCARE SPENDING IN FRANCE, EUROPEAN UNION AND USA FROM 1995 TO 2014, AS A PERCENTAGE OF GDP (A) AND IN CURRENT DOLLARS PER CAPITA (B) (WORLD BANK, 2017) 3
FIGURE 2 - PERCENTAGE OF THE POPULATION OLDER THAN 65 YEARS OLD IN FRANCE, EUROPEAN UNION AND USA FROM 1960 TO 2015 (WORLD BANK, 2017)........ 3
FIGURE 3 - PHOTOGRAPH OF HENRI MONDOR HOSPITAL 6
FIGURE 4 - AR CYCLE (COUGHLAN AND COGHLAN, 2002: 230) 22
FIGURE 5 - PROBLEM-SOLVING CYCLE (A) AND RESEARCH CYCLE (B) IN AR (MCKAY AND MARSHALL, 2001: 50–1) 23
FIGURE 6 - DUAL CYCLE OF AR (MCKAY AND MARSHALL, 2001: 52) 23
FIGURE 7 - RELATIONS BETWEEN RESEARCH QUESTIONS AND THE CHAPTERS OF THIS DISSERTATION........ 30
FIGURE 8 - ALTERNATIVE VIEW OF THE DISSERTATION AND ITS RELATION TO THE INTERVENTION AT HENRI MONDOR HOSPITAL........ 31
FIGURE 9 - PATIENT PATHWAY FOR OUTPATIENT CHEMOTHERAPY WITH PATIENT CATEGORIES AND RESOURCES........ 38
FIGURE 10 - 11-WEEK SCHEDULE FOR THE XELOX (X), MAYO CLINIC (M) AND ROSWELL PARK (R) REGIMENS (ONLY WORKING DAYS ARE INDICATED) 44
FIGURE 11 - INTRA-DAY PLANNING FOR SIX PATIENTS FOLLOWED BY THE SAME NURSE, WITH XELOX (X), MAYO CLINIC (M) AND ROSWELL PARK (R) REGIMENS (EACH HOUR IS DIVIDED IN 15-MINUTES PERIOD)........ 45

Figure 12 - Stakeholders for outpatient chemotherapy in the studied hospital........ 48
Figure 13 - The VSM with all constitutive systems numbered (adapted from Beer, 1985)........ 58
Figure 14 - Research framework integrating the VSM and the 8 steps........ 62
Figure 15 - The divisions, departments and units considered in this study. 63
Figure 16 - Seven-stage model of SSM, adapted from (Checkland and Scholes, 1990) 80
Figure 17 - Screenshot of ARENA, the DES software used in this study 81
Figure 18 - The model for service blueprints 81
Figure 19 - Sequential view of the method 82
Figure 20 - Chronology of the project 83
Figure 21 - Conceptual model with the perspectives of different agents........ 84
Figure 22 - Three examples of root definitions (CATWOE) elaborated during AR Cycle 1........ 85
Figure 23 - Evaluation of scenarios 87
Figure 24 - Impact of advanced preparation on patient waiting times........ 87
Figure 25 - Effect of advanced preparation with a 20% increase of the number of patients. 88
Figure 26 - Main steps in the blueprint for the redesigned process........ 89
Figure 27 - SD model of a general hospital 101
Figure 28 - Projections of raw incidence of breast cancer among women in the Val-de-Marne department (Pop: population, Inc: incidence)........ 102
Figure 29 – Decision framework for the choice of hospital 103
Figure 30 - Matrix M shows which actors have influence over which others 104
Figure 31 - Matrix M+M² (diagonal cases set to zero) shows which actors have length-two influence over others 105
Figure 32 - Converging and diverging logics in the interventions described in this dissertation 114
Figure 33 - Chronological view of the envisioned global program........ 115
Figure 34 - Conceptual model of outpatient chemotherapy delivery process, used for developing the DES model.. 122
Figure 35 - Number of patients per day (simulated and empirical)........ 123
Figure 36 - Cumulative distributions for waiting time (a) and time in treatment room (b) 123
Figures 37a, 37b and 37c - Sources for the binary DSM analysis in Chapter IV........ 127

Résumé

Les hôpitaux se sont traditionnellement organisés suivant une logique fonctionnelle selon deux axes : par organe pour les spécialités cliniques et chirurgicales et par type d'expertise (imagerie, biologie, pharmacie, etc.) pour les autres spécialités. Cette organisation permet de concentrer l'expertise et correspond à la structure disciplinaire des formations en médecine. Néanmoins, elle ne prend pas en compte les contraintes opérationnelles de délivrance des soins. En effet, les parcours des patients requièrent bien souvent l'intervention de plusieurs spécialités. En cancérologie, il n'est pas rare de voir un patient séjourner en chirurgie, en radiothérapie, en oncologie pour une chimiothérapie, pour laquelle il mobilisera également l'unité spécialisée de la pharmacie, tout ceci s'accompagnant d'actes d'imagerie et de biologie. Des problèmes de planification ou de perte d'information se produisent aux interfaces entre ces unités et ont d'importantes conséquences : délais d'attente, risques liés aux prescriptions multiples ou encore opérations réalisées en double.

Toutes les parties prenantes appellent de leurs souhaits l'intégration et la coordination entre services, la définition de parcours-patients transversaux ou l'organisation « par processus » telle que pratiquée dans l'industrie. Pour autant ces nouvelles organisations sont difficiles à mettre en place, du fait de la variabilité des cas à considérer, des enjeux politiques entre services, d'une comptabilité inadaptée, ou par manque de temps, de moyens et de compétences pour réaliser les changements nécessaires. Du point-de-vue de la recherche en génie industriel, en management des opérations et en recherche opérationnelle, les tentatives de transferts méthodologiques depuis l'industrie (Lean ou simulation par exemple) se heurtent à des différences organisationnelles qui rendent leur application directe difficile.

Ces travaux de recherche s'intéressent au problème de la coordination entre services. Ils visent à offrir des méthodes pour améliorer cette coordination et à expliquer les difficultés qui empêchent d'atteindre cette ambition. Le cas d'application est la chimiothérapie ambulatoire, et la thèse s'articule autour de trois questions de recherche :

1. Comment concevoir et mener un programme de changement dans un contexte multi-services à l'hôpital ?
2. Comment améliorer la délivrance des chimiothérapies ambulatoires ?
3. Pourquoi la planification stratégique dans les Centre Hospitalo-Universitaires donne-t-elle des résultats décevants par rapport aux contextes industriels où ces approches ont été appliquées avec succès ?

Nos réponses aux deux premières questions sont fondées sur un projet de recherche-action mené au sein de l'Hôpital Henri Mondor, à Créteil. Nous y avons travaillé à la coordination entre l'hôpital de

jour d'oncologie, où sont administrées les chimiothérapies en ambulatoire, et l'unité pharmaceutique de reconstitution des cytotoxiques, où les chimiothérapies sont préparées.

Dans un premier temps, nous avons travaillé à la structuration d'un programme d'amélioration et à son lancement, grâce à la combinaison de deux méthodes : le Viable System Model (VSM) et les 8 étapes de conduite du changement. Cette approche a permis d'identifier les points bloquants dans le système, par rapport à la vision « idéale » d'un système pérenne fournie par le VSM, et de lancer simultanément des actions de changement destinées à répondre aux problèmes identifiés, ce grâce aux 8 étapes. Cette première phase de projet met en évidence des facteurs influents sur la coordination, à la suite de travaux récents menés sur le sujet. Elle offre une méthode qui complète les manques du VSM et des 8 étapes, tels que le manque de processus de changement dans le VSM, qui est « seulement » un modèle d'organisation, et le manque de vision-cible dans les 8 étapes, qui prennent en compte uniquement le processus de conduite du changement. Cette première phase a amené à la définition de deux projets de changement plus précis, qui constituent le programme de changement de l'hôpital :

- la redéfinition du processus de prescription-préparation-délivrance des chimiothérapies, en insistant sur le partage d'information et la coordination pharmacie-hôpital de jour ;
- la définition d'une vision à moyen-long terme pour le système avec, en particulier, une approche prospective de l'activité future du système.

Le projet de redéfinition de processus, également conduit en recherche-action, a suivi une approche de conception outillée par des méthodes de recherche opérationnelle et de marketing : *Soft Systems Methodology*, simulation à événements discrets, *benchmarking* et *service blueprinting*. Il a permis de faire émerger une nouvelle organisation et de lancer son déploiement. Le concept retenu est celui d'une plateforme de communication entre l'hôpital de jour et les patients, qui permettra de recueillir des données d'état du patient quelques jours avant sa chimiothérapie, de façon à en anticiper la préparation. Ce concept est identifié par des visites dans d'autres hôpitaux, comparé à d'autres et validé par simulation, puis raffiné par une approche de conception de processus, le *service blueprinting*. Combiné à une revue systématique des travaux sur la chimiothérapie ambulatoire, il nous permet de répondre à notre deuxième question, en proposant comme concept-solution aux problèmes d'attente des patients en chimiothérapie ambulatoire cette méthode d'anticipation.

Le projet de prospective/planification stratégique a été traité de façon conceptuelle, puisque les tentatives pratiques se sont heurtées aux spécificités du « marché » de la santé. Nous avons donc pris le parti d'analyser l'hôpital public universitaire suivant deux perspectives, pour expliquer les barrières que nous avons rencontrées. Nous avons tout d'abord analysé l'hôpital dans son environnement, pour montrer que la structure du système de santé n'offre que très peu de moyens aux hôpitaux publics pour attirer les patients, qu'il s'agisse de politique de prix, de qualité ou de localisation, et qu'ils subissent donc une forte incertitude sur l'évolution de leur activité. Nous avons ensuite modélisé par analyse structurale le système de gouvernance des centres hospitalo-universitaires français, pour mettre en évidence la densité des relations politiques et la triple ligne de gouvernance administrative, médicale et universitaire. Cette structure rend improbable l'application directe de modèles de planification développés pour des organisations hiérarchisées et à ligne de gestion unique. Ces deux éléments (incertitude sur la demande doublée d'une absence de moyens d'actions associés, et système de gouvernance intriqué) nous paraissent expliquer, au moins partiellement, les difficultés que rencontre la planification stratégique dans les centres hospitalo-universitaires, ce qui nous permet de répondre à notre troisième question de recherche.

Abstract

Hospitals are traditionally organized on a functional pattern. This model is structured along two dimensions: by organ for clinical specialties, and by type of expertise for other specialties (imaging, pharmacy, biology, etc.). This organization is useful to concentrate expertise and is similar to the structure of medical curricula. However, it does not account for operational constraints in care delivery. Care pathways often involve more than one medical specialty. For instance, in cancer care, a patient may require surgery, radiotherapy and chemotherapy, all located in different departments in the traditional hospital organizations. Imagery, biology and pharmaceutical interventions may also be needed. In such cases, planning issues and information loss happen at the interfaces between units. The consequences are diverse: delays for patients, risks due to multiple prescription or interventions being carried twice.

Faced with this situation, all stakeholders call for more integration and coordination between departments. A shift towards process organization, as practiced in other industries, is often proposed through the definition of transversal care pathways. However, new organizations are difficult to implement because of the variety of cases, of the internal politics, of unfit accounting practices or for lack of time, means and methods to conduct the required changes. Research in operations management, operations research or industrial engineering has tried to help with this process for a long time, but the transfer of methods that were successful in other sectors (Lean management or simulation methods for instance) is not straightforward.

The works described in this dissertation address the issue of interdepartmental coordination. The objective is to define new methods to improve it, and to explain the barriers that stand in the way of enhanced coordination. The application is in outpatient chemotherapy, and the dissertation is organized around three research questions:

1. How should a change program in a multi-department setting be designed and managed?
2. How can one improve outpatient chemotherapy delivery?
3. Why do strategic plans look so disconcerting and disappointing in Public Academic medical Centers (PAMCs) compared to other industrial firms, when similar methods are applied?

Our answers to the two first questions rely on an action-research project at Henri Mondor hospital (Créteil, France). We worked on the coordination between the outpatient oncology unit, where outpatient chemotherapies are delivered, and the pharmaceutical unit that prepares the drugs.

We first tackled the definition and launch of a change program to improve coordination. To do so, we combined two methods: the Viable System Model (VSM) and the 8 steps for leading change. With

this approach we identified blocking points in the system by comparison with the “ideal” vision of a viable system embodied by the VSM. We simultaneously started improvement projects to address the issues identified, following a change process informed by the 8 steps. This first phase also allowed us to identify influent factors for interdepartmental coordination. The proposed approach is complementary to both the VSM and the 8 steps, as the VSM is “only” a model without a change process, while the 8 steps offer a change process but no support to build the future vision.

At the end of this first phase, two more precise change projects were defined:

- The redefinition of the prescription-mixing-delivery process for chemotherapies, with a focus on information sharing and coordination between the oncology department and the pharmacy;
- The elaboration of a mid/long-term vision for the system, with an emphasis on prospective scenarios of future workload.

The process redefinition was carried as an action-research project. It followed a design approach, using tools from operations research and marketing: Soft Systems Methodology, discrete event simulation, benchmarking and service blueprinting. A new process was defined and its implementation was started. The main new concept is to use a communication platform between the hospital and its patients. On this platform, patients will be asked to provide information a few days before their chemotherapy, so that their status can be medically assessed and the preparation of their drugs can be anticipated. This concept was identified in other hospitals that we visited, it was simulated to be compared to other scenarios, and it was refined into a workable business process with service blueprinting. Thanks to this project, and the results of a systematic review of works on outpatient chemotherapy, we can answer our second question and propose the concept we used as a solution to problems of patients waiting times in outpatient chemotherapy.

The strategic planning/prospective project was addressed at a more conceptual level, since tentative implementations were blocked by the very specific organization of the healthcare “market”. We decided to analyze public academic hospitals from two different but complementary perspectives to explain the issues we encountered. We first analyzed the operations of the hospital in relation with its environment in order to show that the structure of healthcare markets gives little opportunity to PAMCs to attract patients through the definition of their offer. The definitions of pricing, quality and geographical access, and their impact on patient behavior, differ largely from traditional industries. Hospitals thus face a high uncertainty on the evaluation of their workload. We also modelled the governance system in French PAMCs with structural analysis. The model evidenced an intricate political network and a triple power line: administrative, medical and academic. It is unlikely that with this structure the direct transfer of planning methods defined for traditional, hierarchical organizations can be successful. The dimensions identified (uncertainty on demand coupled with a lack of available control actions, and the complex governance system) contribute to explain the difficulties in strategic planning for PAMCs. These elements constitute our answer to our third question.

Introduction

In this chapter, we first present in Section 1 the general context of our work: the healthcare sector and cancer care, and the issue of care coordination in hospitals. We then introduce the specific context of our project in Section 2, by describing Henri Mondor hospital and the characteristics of our intervention there. This leads us to formulate three research questions in Section 3. In Section 4, we give an overview of the relevant research fields that can help to answer our questions. In Section 5, we do the same with the associated research methodologies. This summary of the research context allows us to frame our project and detail our research approach in Section 6. Finally, Section 7 lays out the structure for the remaining of the dissertation.

1. General Context

1.1. Challenges in Healthcare Systems

Healthcare systems around the world are under pressure. Figure 1 shows the evolution of healthcare spending in France, the USA and the European Union. Both as a percentage of GDP and in current dollars per capita, the figures are increasing. Although France is not in the same situation as the US, where almost 17.5% of GDP goes to healthcare spending, healthcare cost increased from 10% to 12% of GDP in twenty years.

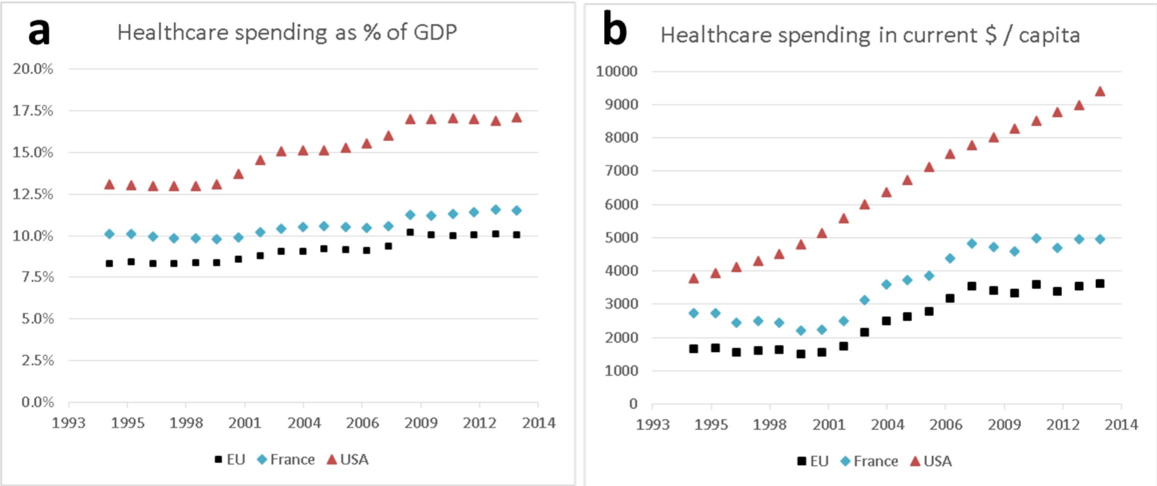


Figure 1 - Healthcare spending in France, European Union and USA from 1995 to 2014, as a percentage of GDP (a) and in current dollars per capita (b) (World Bank, 2017)

The demand for care is not likely to decrease. Figure 2 shows the evolution of the percentage of the population aged 65 and above in the three same areas. In France end the EU, this proportion was a little above 10% in 1960 but is steadily increasing and should soon reach 20%.

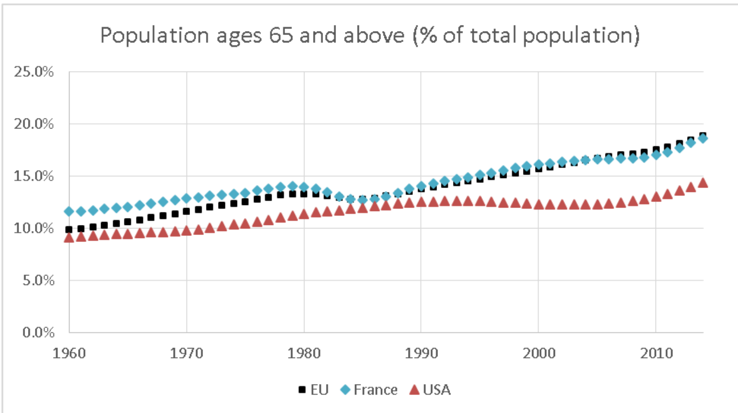


Figure 2 - Percentage of the population older than 65 years old in France, European Union and USA from 1960 to 2015 (World Bank, 2017)

All diseases do not have the same impact. In developed countries, with their ageing population and the good level of care for most avoidable death causes, cancer has become one of the main causes of death (Lozano et al., 2012) and a huge challenge for healthcare systems.

1.2. Cancer Care

Epidemiology and Associated Socio-Economic Impacts

8.2 million people around the world died from cancer in 2012 (Ferlay et al., 2015). Direct costs for cancer care are expected to reach $173 billion in 2020 in the United States (Mariotto et al., 2011). The global cost (which includes cost of care and productivity losses) of cancer is evaluated at 126 billion euros for the European Union in 2009, of which 51 billion euros for healthcare systems (Luengo-Fernandez et al., 2013). Given this devastating impact, cancer is a major priority for the healthcare system of every developed country. The situation is preoccupying, because none of these trends is likely to change radically: based on 2004-2006 US data, the lifetime probability of being diagnosed with an invasive cancer in the US was estimated at 44% for men and 38% for women (Jemal et al., 2010).

Different types of treatment exist for cancer. Chemotherapy, surgery, radiotherapy are the three main options. Our work focuses on outpatient chemotherapy clinics.

Outpatient Chemotherapy

Chemotherapy can be prescribed as a standalone treatment, or in parallel or in sequence with radiotherapy or surgery. Chemotherapy is mainly delivered by outpatient clinics. Outpatient cancer care accounted for 63% of total cancer care costs between 2001 and 2005 in the US (Tangka et al., 2010), and its cost is rising fast: from $25.5 billion in 2001 to $43.8 billion in 2011 in the US (Soni, 2014). In France, the number of outpatient chemotherapy sessions increased by 4.4% between 2011 and 2012, and the cost of outpatient chemotherapy (89.3% of all chemotherapies) increased by 8.8% in the same interval (Institut National du Cancer, 2014).

1.3. Hospital Coordination

In the situation we just described, there is a clear need for an increase in efficiency in the healthcare system regarding cancer care. In France, hospitals have been identified as offering opportunities for high efficiency gains (Cour des Comptes, 2014). Better coordination between professionals and between organizations is seen as a way forward. We next define care coordination and its application to hospitals.

General Definition of Care Coordination

Gittell and Weiss (2004: 135) report the words of a hospital administrator: “We’ve moved from patients experiencing individuals as caregivers to patients experiencing systems as caregivers. There's less time to build individual relationships with the patient. It's not just individual brilliance that matters anymore. It's a coordinated effort.” This quote reflects the fact that with the development of ambulatory care, the customization of care based on personal preferences and the growing number of resource-intensive cases in an ageing population, care coordination is needed.

Care coordination has been defined as “the deliberate organization of patient care activities between two or more participants (including the patient) involved in a patient's care to facilitate the appropriate delivery of healthcare services." (McDonald et al., 2007: 5). Therefore care coordination is deeply concerned with complexity aspects: it involves the organization of multiple activities, spread in time, between different actors with potentially different objectives and value systems, to care for someone whose state is likely to evolve in sometimes unpredictable fashions. Multiplicity and diversity of actors, interdependence between their decisions, and uncertainty on the effects of these decisions: all of these are generally accepted as complexity factors. To describe this situation, Klein and Young (2015) label healthcare as "hypercomplex".

The consequences of insufficient coordination are major. Lack of coordination can be a threat for patient safety and generate accidents (Nyssen, 2007), delays (Lamé et al., 2015; Vegting et al., 2011), unadequate drug prescriptions leading to adverse drug reactions (Schoen et al., 2005), loss of information during patient transfers (Bodenheimer, 2008) or untimely delivery of results or duplication of tests (Schoen et al., 2004).

Coordination in Hospitals

Hospitals are a major component of the healthcare industry, and they have long-since been considered as complex organizations (Georgopoulos and Matejko, 1967). They are still often fragmented organizations, making the move towards higher efficiency a challenge. Besides, hospitals differ from more "traditional" industrial firms in many aspects: large number of stakeholders which influence the strategy (Cuccurullo and Lega, 2013), multidimensional value stakes (Young and McClean, 2009) and structural specificities in the balance of influence and power between boards and frontline (Lega and DePietro, 2005). To meet the efficiency and efficacy targets of hospitals, integration is often proposed as a way forward (Glouberman and Mintzberg, 2001; Lillrank, 2012), with support from systems approaches suggested as promising (Reid et al., 2005; Tien and Goldschmidt-Clermont, 2009). Yet, Drupsteen et al. (2016) explain that besides injunctions to integrate services and general success factors, there is a lack of knowledge at the operational level on the factors that impact on integration.

The situation is not very different with regards to the methods and processes capable of creating integration. Many industrial approaches from Operations Management (OM)/Operations Research (OR) have been tried, but the results are mixed at best. In OM, the lack of evidence supporting Lean management impact on hospital performance is disappointing. In OR, the lack of integrative, multidepartment modelling studies has been reported (Hulshof et al., 2012; Vanberkel et al., 2009), and many studies fail to move to the implementation stage (Jahangirian et al., 2012).

In this work, we wish to reach higher efficiency through enhanced integration and coordination between hospital departments. Although efficiency is sometimes reduced to cost-efficiency, this is not fit for the healthcare sector, and our perspective is wider. It is in line with the "Triple Aim" defined by Berwick et al. (2008: 759): "improving the experience of care, improving the health of populations, and reducing per capita costs of health care". We consider patient satisfaction and medical quality of care to be as important dimensions as resource-efficiency, and we also integrate the satisfaction of healthcare professionals in our vision of performance. Ideally, we aim at improving all these dimensions, or at least to improve some dimensions without decreasing performance on others.

2. Context of this Work

In order to identify solutions to the efficiency challenge through improved coordination, we have worked in collaboration with a French public academic hospital, Hôpital Henri Mondor. We next describe this hospital. Then we present arguments supporting partnerships between hospitals and researchers in management, and we detail the form of collaboration we developed in this particular case. Finally, we present the initial demand that was formulated at the beginning of our work at Henri Mondor hospital.

2.1. Presentation of Henri Mondor Hospital

Henri Mondor hospital is a public university hospital in Créteil, near Paris, France. It has 1,300 beds and 120 day-hospital spots. It is part of Assistance Publique – Hôpitaux de Paris (AP-HP), the largest hospital group in Europe, with 37 hospitals, a budget of 7 billion euros, 90,000 employees and 7 million patients annually. Henri Mondor hospital is linked to Université Paris-Est Créteil (UPEC) for teaching and research. Henri Mondor hospital employs 4,000 people.

Figure 3 - Photograph of Henri Mondor hospital[1]

The Laboratoire de Génie Industriel (LGI) of CentraleSupélec has signed a partnership with a structure of the hospital, the Hospital-University Department on Virology, Immunology and Cancer. This partnership comes after a long history of research in healthcare in this lab (10 PhD defended in the healthcare sector since 2007). The head of the "care" dimension of the Hospital-University Department is Pr. Pierre Wolkenstein, also head of the Cancer – Immunology – Tranplant – Infectiology division of the hospital.

2.2. Collaborative Research with Henri Mondor Hospital

Why Such Partnerships?

There are two types of arguments in favor of partnerships between management researchers and organizations, in particular hospitals. The first kind looks at the interest for research. The second kind focuses on the impact on organizations.

For research, authors have argued that in academia, there is too much reliance on the literature to define problems in OM (Sodhi and Tang, 2014). On the opposite, original problems can be discovered on the field (Corbett and Van Wassenhove, 1993; Guide and Van Wassenhove, 2007). Looking at

1 Picture from http://www.ville-creteil.fr/sante-recherche, consulted January 24th, 2017

OM/OR, Guide and Van Wassenhove identify six reasons for "Partnering with Industry but Publishing in Academia" (2007: 531–3):

- "Working with industry can fulfill two-thirds of the requirements that research be rigorous, relevant, and refreshing"
- "Working with industry is fun and exciting"
- "Working with industry keeps us honest"
- "Practice evolves rapidly"
- "Working with industry demands relevance: P/OM and OR are applied sciences, so relevance is key"
- "Working with industry allows us to show and better understand the true potential of quantitative models"

In the same perspective, De Margerie and Jiang (2011) show that managers look for eye-opening, solutions-oriented and accessible findings when they assess OM research. All of these characteristics require a subtle understanding of the reality of organizations.

The interest is also for practice. With calls to solve healthcare "on the front line" (Bohmer, 2010), but evidence that the mere transfer of methods from industry is not a panacea (see Sections 3.2. and 3.3. for examples), new methods must be developed. The transfer of knowledge is not an easy process and is often problematic. Some authors have argued that the problem is not even one of transfer, but one of creation of knowledge: that practical knowledge and academic knowledge are of different kind, and that the co-creation of practical knowledge should be a valued aim in academia (Van de Ven and Johnson, 2006).

Researcher's Position

Given the arguments presented above, we have opted for a practice-oriented, pragmatic approach to our research. This position is influenced by theoretical concepts such as Mode 2 research (Nowotny et al., 2003) and engaged scholarship (Van de Ven and Johnson, 2006). Section 6 shows how we apply it to our research. Regarding our position in the hospital, our work can be related to the researcher-in-residence model (Marshall, 2014; Marshall et al., 2014, 2016), where a researcher is detached from his lab to an external organization.

> *"The Researcher-in-Residence model is presented as a practical way of addressing the traditional barriers which often prevent health service researchers and health service decision makers from sharing their expertise for the benefit of patients. The model adds value to other participative initiatives by emphasising a 'meeting of equals' between researchers and practitioners, by building on learning from outside the health sector, and by having a robust historical, conceptual and philosophical foundation. In addition, it frames a complex process in a way that is attractive to the participants and to funders."* (Marshall et al., 2014: 803)

This description concurs with our experience. We had no contractual link to Henri Mondor hospital, other than the convention between the hospital and our laboratory. This guaranteed our independence.

2.3. Initial Demand

Our work focuses on cancer care. In this sector, Henri Mondor hospital has three expert centers, for urology, hematology and digestive cancers. It offers the full range of mainstream cancer treatment:

chemotherapy, mainly in the hematology, medical oncology and dermatology departments; radiotherapy; and surgery, in the digestive surgery and plastic surgery departments. The decision to study cancer care delivery was opportunistic, after a good contact was established with the head of the medical oncology department, Pr. Christophe Tournigand. We later included in our work the unit dedicated to cytotoxic drugs in the pharmacy, headed by Dr. Muriel Carvalho.

The oncology department is divided between outpatient and inpatient units. Around 4,000 outpatient chemotherapy sessions take place every year in the outpatient unit. Each day, three nurses, two oncologists and three nursing assistants are directly involved in the outpatient chemotherapy process. All cytotoxic drug preparations take place in a centralized unit, which prepares around 20,000 chemotherapy doses per year (around 80 preparations per day on average). There are five pharmacy assistants working directly for the preparation, two pharmacists for validation of prescriptions, and one technician in charge of the analytic control of the preparations. This could be qualified as a medium-sized facility compared to other hospitals who deliver chemotherapies.

At the beginning of our work at Henri Mondor hospital, the global trend is an increase of the number of patients and drug preparations: +10% drug preparations and +19% outpatient oncology sessions between the first semesters of 2014 and 2015. In this context, the head of the oncology department worries that his patients are waiting a lot when they come for a chemotherapy. Our first analysis showed that half of the patients waited more than one hour between their medical appointment and the beginning of chemotherapy infusion, with 25% of the patients waiting more than 80 minutes. Overall, during the observations, 35% of the cumulated patient time in the hospital was spent waiting. This situation is perceived as a double problem:

- A service quality problem, as patients have an appointment time but still have to wait;
- A capacity planning problem, as a patient who waits occupies a treatment seat, a critical resource in outpatient chemotherapy. Waiting patients also need nursing attention.

The objective of the project was to identify the most efficient actions to reduce waiting times. The initial perimeter was restricted to the outpatient oncology unit, but was later extended to get a more comprehensive view of the cancer care activities in the hospital.

3. Research Questions

The initial demand from the head of the oncology department, a preliminary analysis of the literature on hospital coordination, and our observations on the field led us to formulate three research questions. We next present these questions, and detail them into sub-questions.

1. How should a change program in a multi-department setting be designed and managed?

We start from a "problematic situation", rather than a well-defined problem. Our objective is to support the change process from this situation into a more desirable one. This yields two sub-questions:

1a. How can one concurrently structure and trigger a change program in a multi-department setting?

Faced with the initial demand, we had to quickly apprehend the organization, extract its most important aspects given our problem, and use this information to plan for action that would lead to improvements.

1b. How should one proceed to redesign processes routinely involving two or more hospital departments?

Starting a change program, giving the first impulse based on a change "strategy", is one thing. But we then needed to make things concrete, to support the definition of new operational procedures to bring about the desired improvements.

2. How can one improve outpatient chemotherapy delivery?

Our empirical work focuses mainly on outpatient chemotherapy. We show in Chapter I that outpatient chemotherapy is a very specific activity. This leads us to ask two sub-questions:

2a. What quantitative models have been developed for studying and improving outpatient chemotherapy planning, and how relevant are they compared to practice?

The specific domain of outpatient chemotherapy has never been reviewed. It is a small area in the literature, but it covers a specific problem. Therefore it is important to ask what has been done in the past to model this activity.

2b. Is there a robust concept that would allow for a reduction in patient waiting times in outpatient chemotherapy?

In other words, is there a solution that is likely to apply to a wide range of outpatient chemotherapy clinics in the world?

3. Why do strategic plans look so disconcerting and disappointing in PAMCs compared to other industrial firms, when similar methods are applied?

Strategic plans are supposed to help focusing all efforts in one agreed direction, therefore they should play a role in coordination. However, the planning process in PAMCs is reported to produce disappointing results. Why this situation? What characteristics make PAMCs different from other firms where strategic planning is more successful?

4. Related Research Fields

To answer to the previous questions, we work in-between several research fields. The broadest field is Health Services Research (HSR), a multidisciplinary field of investigation that studies healthcare in its organizational dimension. However, given the orientation of this work towards learning through problem-solving, we build on other fields: Systems Thinking and Systems Engineering, Operations Management, and Operations Research. These fields are not imperviously separated. For instance, systems thinking has had an important impact on OR, with the Soft OR stream. However, these research fields have different historical sources, and it is based on this perspective that we separate them.

We now describe HSR. We then present each of the three disciplines that we use in this work. For each, we present elements of theoretical background and definition of the field. We then discuss the application of this discipline in healthcare, and the challenges it faced. Our position regarding these fields and how they connect to our research is presented in Section 6.

4.1. Health Services Research (HSR)

To describe HSR, we use the definition adopted in 2000 by the Board of Directors of the then Association for Health Services Research (AHSR, which has become the Academy for Health Services Research and Health Policy and is today known as AcademyHealth):

> *"Health services research is the multidisciplinary field of scientific investigation that studies how social factors, enhancing systems, organizational structures and processes, health technologies, and personal behaviors affect access to healthcare, the quality and cost of healthcare, and ultimately our health and well-being. Its research domains are individuals, families, organizations, institutions, communities, and populations."* (Lohr and Steinwachs, 2002)

On January 18th, 2017, 89 journals were registered in the corresponding field (*Healthcare Sciences & Services*) in ThomsonReuters' Journal Citation Report (Thomson Reuters, 2016). HSR includes a range of subfields. For instance, quality improvement/improvement science (Marshall and Mountford, 2013), starting in the 1960's (Donabedian, 1966), studies methods to define, evaluate and improve the performance of healthcare. Implementation science (Bauer et al., 2015; Foy et al., 2015) addresses the diffusion of research results and Evidence-Based Practices (clinical or organizational) in healthcare organizations.

Being essentially multidisciplinary, HSR welcomes contributions which could methodologically or disciplinarily be otherwise classified as management, OR, economy, ergonomics, psychology or sociology (the list is not exhaustive). We now present three of these disciplines, starting with systems engineering and the broader field of systems thinking.

4.2. Systems Thinking, Systemics and (Healthcare) Systems Engineering (SE)

In this sub-section, we give some background elements on systems thinking and its main concepts. We then present the different theoretical orientations in modern systems thinking applied to organizations. Finally, we discuss why systems thinking appears necessary in healthcare.

Background: Definitions

Sub-section 4.2 could also have been entitled "the systems movement", which is a broad theoretical movements encompassing engineering, social science and natural science aspects. A full history of the systems movement is beyond the scope of this manuscript. Interested readers are referred to (Checkland, 1981; Durand, 2013; Jones-Rooy and Page, 2010; Le Moigne, 1977, 1990) for more details. Le Moigne (1977) argues that the systems movement stems from the encounter of structuralism with cybernetics, to which Durand (2013) adds Information Theory. An important companion to (or manifestation of) systems thinking is complexity science and complexity thinking. In our case, it is best embodied by Edgar Morin's precepts (1990).

The common ground that lays the foundation for the systems movement is the interest in interacting entities, and open systems thinking. Entities are no longer considered for themselves, but as parts of larger units, where they interact with other entities through various types of flows—energy, information, matter… Interacting entities form systems, i.e. “a regularly interacting or interdependent group of items forming a unified whole” (*Merriam-Webster Dictionary*, n.d.), or “a complex whole the functioning of which depends on its parts and the interactions between those parts.” (Jackson, 2003: 1)

Paradigms inside Systems Thinking for Organizations

Systems thinking is the use of systems as conceptual objects to apprehend the world, understand it and act on it. Systems thinking applies to all sorts of objects, from aircrafts to governments. However, the type of object is determinant in the choice of systemic approaches and the dimensions of the model. In our work, three paradigms are of particular interest: the positivist-functionalist paradigm, the structural-functionalist paradigm, and the interpretive paradigm.

The traditional paradigm in SE combines a positivist epistemology with a functionalist perspective on organizations. In a positivist epistemology, knowledge is based on events that have actually been observed: reality is “reduced” to events that actually occurred and have been observed and measured (Mingers, 2014: 55). Experimental natural sciences rest on this paradigm. The functionalist paradigm in social sciences is described by Jackson:

> *“The functionalist paradigm takes its name from the fact that it wants to ensure that everything in the system is functioning well so as to promote efficiency, adaptation and survival. It is optimistic that an understanding can be gained of how systems work by using scientific methods and techniques to probe the nature of the parts of the system, the interrelationships between them and the relationship between the system and its environment. The expertise it provides should put managers more in control of their operations and organizations, and enable them to eliminate inefficiency and disorder.”* (Jackson, 2003: 38)

Therefore, in a functionalist-positivist paradigm in management science, variables have to be measured, in order to ease the control of the organization. This perspective has often been labelled “mechanistic”, and encompasses most traditional, Hard SE, Hard OR approaches, where “the inspection of the world by the observer will reveal it to contain systems” and that these systems can be named, and can be manipulated in the interests of efficiency” (Checkland, 1981: 277). Examples of methods are linear programming, statistical regression models, survey research, and optimization algorithms.

Structuralism differs from positivism as it supposes that observable events are the result of underlying structures that connect entities. The role of the researcher is to unveil these structures. Cybernetics adds the notion that an entity may influence itself through feedback loops, and that systems react mainly to stimuli from their environment. The encounter of the structuralist and cybernetic perspectives with the functionalist view in social sciences results in a structuralist-functionalist paradigm, where the arrangement of entities into hidden structures conditions the emergence of certain behaviors and functions. The aim is to provide more control to the manager over the emergent behavior, to achieve higher efficiency and efficacy (functionalism). This is the theoretical underpinning of some well-known OR methods, such as system dynamics or the Viable System Model (VSM).

The fact that what Checkland refers to as “human activity systems” include purposeful human-beings, able to reflect on their own activity, leads us to the interpretive paradigm, which recognizes that all participants in such systems may not share the same goals, and that their goals do not necessarily add up to define a global goal for the system. Jackson describes the interpretive paradigm as follows:

> *"Organizations happen, and people act and interact in organizations, as a result of their interpretations. This paradigm wants to understand the different meanings people bring to collaborative activity and to discover where these meanings overlap, and so give birth to shared, purposeful activity. Managers can be guided to seek an appropriate level of shared corporate culture in their organizations. They can take decisions, on the basis of participative involvement, that gain the commitment of key stakeholders."* (Jackson, 2003: 39)

Checkland based his Soft Systems Methodology on this paradigm. It seems particularly suitable for pluralist organizations, where consensus, debate and mutual adjustment are more customary than hierarchical control and imposed procedures.

Rationale for Systems Thinking and SE in Healthcare

Systems thinking and SE tools are widely used in healthcare. There have been calls for applying more SE tools in healthcare, including from the National Academy of Engineering and the Insistute of Medicine (Reid and Grossman, 2005). Besides classic predictive insights expected from modelling, systems modelling is argued to help testing the viability of policy interventions quickly and inexpensively, provide guidance on what data should be collected, raise new questions for research, and "reinforce what Epstein calls a "militant ignorance", or commitment to the principle that "I don't know" as a basis for expanding scientific knowledge." (Peters, 2014: 6) More and more articles are now published in the HSR literature to introduce systems modelling (Pitt et al., 2016; Swanson et al., 2012; Willis et al., 2012).

Some of the research on systems thinking and modelling in healthcare has been published in SE literature, in journals such as *IEEE Systems Journal*, *Journal of Systems Science and Systems Engineering* or *IEEE Transactions on Systems, Man and Cybernetics*), e.g. (Augusto and Xiaolan Xie, 2014; Fanti et al., 2013; Fradinho et al., 2014; Tien and Goldschmidt-Clermont, 2009). However, other fields are involved, in particular OR (Brailsford and Vissers, 2011), OM (White et al., 2011) and HSR (Elf et al., 2007; Jun et al., 2011).

4.3. (Healthcare) Operations Management (OM)

In this Sub-section, we first define OM. We then discuss some challenges in the application in healthcare of OM principles initially defined in the manufacturing sector.

Definition

> *"Operations management is the activity of managing the resources which are devoted to the production and delivery of products and services."* (Slack et al., 2009: 4)

> *"Operations management decisions can range from long-term, fundamental decisions about what products or services will be offered and what the transformation process will look like to more immediate issues, such as determining the best way to fill a current customer order. Through sound operations management, organizations hope to provide the best value to their customers while making the best use of resources."* (Bozarth and Handfield, 2008: 7)

As a scientific discipline, research in OM focuses on the practice of OM. It has its roots both in Taylorian production engineering, and in the social science roots of management research. A key element in OM research is its process approach to production, which is viewed as a transformation of certain inputs into certain outputs of interest. The transformation is made possible by the consumption of the organization's resources: energy, worker time, machine time, knowledge, facilities.

Challenges in Healthcare OM: the Example of Lean Manufacturing/Management

An example of a methodology in OM is Lean manufacturing, with its various management tools, such as Kanban and visual management. Lean management was formalized in the 90's under the inspiration of Japanese operations management (Womack et al., 1990). It has widely spread in the manufacturing sector and has then been adapted to service management. After it was empirically studied, Lean manufacturing has been tied to the OM theory of swift, even flow (Schmenner, 2001, 2012). Lean manufacturing/Lean management has been used in interventions in healthcare (D'Andreamatteo et al., 2015), and the theory of swift, even flow, has been used as a theoretical framework for descriptive studies (Fredendall et al., 2009). The case of Lean is interesting because Lean has been pushed on public hospital managers in many countries. Healthcare organizations have started Lean programs, hoping to replicate the improvements witnessed in some manufacturing contexts. However, the results in healthcare are quite disconcerting.

In the 167 studies reviewed by D'Andreamatteo et al. (2015: 1203), "over 50% referred to increased productivity and cost efficiency", and "no negative effects were reported, except for some cases in the emergency department". A survey of 211 US acute care hospitals by Dobrzykowski et al. (2016) shows that a comprehensive Lean orientation improves patient safety and is positively tied to hospital income if efforts are made on organizational integration. The literature also offers many positive case-studies (Lamm et al., 2015; Sullivan et al., 2014; van Lent et al., 2009), including mixed approaches where Lean is combined with other methods (Baril, Gascon, Miller and Cote, 2016; Robinson et al., 2012)

However, other reviews conclude that there is no definitive evidence of the impact of Lean management projects on hospital performance (Andersen et al., 2013). Vest and Gamm (2009) report only positive results in the studies they review, but highlight serious methodological limitations, a concern shared by Moraros et al. (2016). Besides, reported implementations of Lean are mostly partial, with very few "system-wide approach" approaches (D'Andreamatteo et al., 2015). Poksinska et al. (2017) also note a heavy focus on efficiency, but limited concern for and impact on patient satisfaction. Finally, one of the most recent systematic reviews states that "Lean interventions have: (i) no statistically significant association with patient satisfaction and health outcomes, (ii) a negative association with financial costs and worker satisfaction and (iii) potential yet inconsistent benefits on process outcomes like patient flow (reduced patient visits, reduced surgical consults, improved time dependent care) and safety (washing hands, staff checking ID bands and giving patients safety brochures)." (Moraros et al., 2016: 150)

To explain this situation, Young and McClean (2008) state that the transfer of methodologies from general industry to healthcare cannot be immediate. Indeed, a patient-centered approach requires at least two dimensions: efficiency/responsiveness, a typical OM concern, and clinical priorities, a medical imperative. Another challenge is the structure of healthcare organizations, especially hospitals, which is quite different from the classical industrial firm. The empirical study by Andersen and Rovik (2015) backs this assertion as the authors show that Lean management is modified and transformed during its implementation, ending in something possibly far from the initial principles. The complex power structures and the political use of Lean programs is also reported by Waring and Bishop (2010). In a study of quality improvement programs in public hospitals in Quebec, Lozeau et al. (2002) notice that the lack of pressure from customers and the diffuse power structure result in a situation where the main customer of the quality improvement program is the public health authority rather than the customer (i.e. the patient). In the end, the quality improvement program is adopted superficially, "retaining only a ritual function", or even "captured and used to reproduce existing roles and power structures" (Lozeau et al., 2002: 539–40), instead of transforming the organization.

This example shows how difficult it is to transfer practices from other sectors to healthcare, and even more to public academic medical centers. It also exemplifies the difficulty to measure the impact of improvement methods, beyond collections of positive case studies.

4.4. (Healthcare) Operations Research (OR)

In this Sub-section, we first present OR in its traditional form: quantitative, "Hard" OR. We then introduce the Soft OR stream. Third, we present the long history of OR work in healthcare. Finally, we discuss some challenges in the application of OR methods in this sector.

The Traditional Form of OR

OR as we know it today first developed in the military during World War II. After the war, it quickly developed, with dedicated journals and curricula (Kirby and Capey, 1998). Quickly enough, the practice of OR went to be structured as an academic discipline and OR became labelled as a science, with its own methodology (Ackoff, 1956).

An early definition of OR was given by Kittel:

> *"Operations research is a scientific method for providing executive departments with a quantitative basis for decisions. Its object is, by the analysis of past operations, to find means of improving the execution of future operations."* (Kittel, 1947: 150)

Blackett endorses this definition in the first editorial of *Operational Research Quarterly*, to which he adds that OR is "social science done in collaboration with and on behalf of executives." (1950: 4)

What is clear from these two definitions is that OR is a mathematical approach to solve the problems of executives. As such, OR covered various quantitative approaches, from linear programming to simulation, all initially working under a positivist-functionalist paradigm. This perspective is still endorsed today by the US-based Institute for Operations Research and the Management Sciences:

> *"Operations Research (O.R.), or operational research in the U.K, is a discipline that deals with the application of advanced analytical methods to help make better decisions. The terms management science and analytics are sometimes used as synonyms for operations research.*
>
> *Employing techniques from other mathematical sciences, such as mathematical modelling, statistical analysis, and mathematical optimization, operations research arrives at optimal or near-optimal solutions to complex decision-making problems."* (INFORMS, n.d.)

This definition of OR as a rational and quantitative enterprise still prevails in the largest part of the OR community. However, other interpretations of the definition, the mission, the subject of enquiry and the methods of OR have emerged, mainly in the UK.

The Soft OR Stream

In the 1970's, a critique emerged against academic OR. The main leader of this movement was Russel Ackoff, an OR pioneer who then declared that "American Operations Research is dead" (1979: 93). Ackoff's critique was against OR as an academic enterprise detached from practice, focused on ever-more complex models, and working on expired principles. His opinion was that the reductionist and deterministic perspective he saw in OR at the time was out-of-date and should be replaced by a holistic, systemic approach. Ackoff also criticized the quest for optimal solutions, as the optimal solution in the model is unlikely to be optimal in the real system. He argued that managers were not confronted with neatly defined problems, but rather faced "messes", "dynamic situations that consist of complex systems of changing problems that interact with each other." (1979: 99)

The debate started by Ackoff on academic OR's relevance to practice continued until the 1990's (Corbett and Van Wassenhove, 1993). However, in the UK, Ackoff's critique concurred with a reaction to the situation he described. In the 1970's and early 1980's, OR researchers in the UK, infused with systems thinking, with similar critiques as Ackoff's regarding OR's reductionism (Checkland, 1980), started developing new methods. Two main developments which happened during that period fit in the scope of this dissertation:

- Stafford Beer's development of organizational cybernetics, embodied in his Viable System Model (1972, 1979, 1984, 1985)
- Peter Checkland's development of his Soft Systems Methodology (1981; Checkland and Scholes, 1990)

These two developments (and other research in parallel) would initiate the adoption of new paradigms, besides the traditional positivist-functionalist paradigm, in OR: the structuralist-functionalist paradigm with Beer, and the interpretive paradigm with Checkland. Along with other approaches, this new stream would be labelled "Soft OR", or "Problem Structuring Methods (PSMs)"[2]. For a list of Soft OR methods and models, the reader is referred to (Ackermann, 2012; Jackson, 1991, 2003; Mingers, 2011; Mingers and Rosenhead, 2004; Reynolds and Holwell, 2010; Rosenhead, 1996). Despite a growing popularity, the Soft OR movement remains mainly European, and even UK-based (Mingers, 2011).

OR in Healthcare

According to Flagle (2002), OR in healthcare started in 1952 with a series of papers by Norman T. J. Bailey:

- A conceptual paper on "OR in medicine" in *Operational Research Quarterly* (Bailey, 1952b);

[2] The two names do not seem totally equivalent, and Ackermann (2012: 652) describes PSMs as a particular form of Soft OR. There also seems to be a debate about functionalist approaches like Beer's VSM and Soft OR. When Soft OR is defined broadly as *everything which is OR but not quantitative, computational, Hard OR*, the VSM seems to fit in. But sometimes Soft OR seems to be tied to the interpretive and critical paradigms, e.g. when Mingers associates Beer's original use of the VSM to "traditional "hard" techniques" (2011: 733).

- The same year, Bailey also published a paper on outpatient appointment scheduling in the *Journal of the Royal Statistical Society* (Bailey, 1952a), and Welch published on outpatient department design in the *Journal of the Royal Sanitary Institute* (Welch, 1952);
- Finally, Welch and Bailey presented Bailey's results in the *Lancet* (Welch and Bailey, 1952) to publicize OR and queueing theory.

After 1952, OR in healthcare quickly developed, and in 1976, a literature review already identified 188 articles applying mathematical OR modelling to healthcare problems (Fries, 1976). After that, the literature on modelling and simulation in healthcare kept expanding at a fast pace: about 30 articles a day recently (Brailsford, Harper, et al., 2009)! The field of healthcare OR has evolved to have its own scientific journals, such as *Healthcare Management Science* or *Operations Research for Healthcare*, and its dedicated conferences, such as *OR Applied to Health Systems* (*ORAHS*) or *INFORMS Healthcare*. Hard OR remains the main approach, but Soft OR is also applied, and mixed approaches are frequent (see below).

However, despite enthusiasm on part of the OR research community, and clear needs in the healthcare sector, the application of OR in healthcare organizations is not straightforward.

Challenges in Healthcare OR: the Example of DES

OR in healthcare experiences difficulties to make an impact. The limited implementation of OR results in practice has been pointed out since the 1980's (Wilson, 1981). Since then, the situation does not seem to have evolved much. In 2009, Brailsford et al. (2009) reviewed the literature on modelling in healthcare. They identified 176,320 articles on the subject. Only 5.3% of these papers presented actual actions taken based on the insights generated by the models. Another review by Brailsford and Vissers (2011) found implementation rates under 6%.

One may ask if the situation is really different in other sectors. A partial answer can be given in the case of papers using simulation. Jahanagirian et al. (2012) reviewed papers using simulation in healthcare, defense and commerce. They found that only 8% of simulation papers in healthcare are "Real Problem-Solving papers" (projects with "a significant level of user/stakeholder engagement in the simulation part", as opposed to "hypothetical Problem-Solving papers" or "methodological papers"). "Real problem solving papers" accounted for 49% of the simulation papers in commerce and 39% in defense. This situation led Proudlove et al. (2007: 155) to affirm that "the practical contribution of OR has been very limited", a point also made by Fone et al. (2003).

Like in OM, these figures show that the healthcare sector needs specific approaches and that the mere transfer of methods built for other industrial sectors is likely to fail. Some have tried to identify root causes for this situation by identifying barriers and challenges to OR modelling in healthcare (Harper and Pitt, 2004), to the implementation of OR techniques in healthcare routine (Brailsford, 2005) or the specificities of healthcare settings for OR interventions (Tako and Robinson, 2012). The complexity of healthcare organizations and of the problems they encounter is regularly put forward (Harper and Pitt, 2004; Klein and Young, 2015; Tako and Robinson, 2012).

5. Related Methodological Approaches

In relationship with the disciplinary fields presented above, our work is aimed at generating knowledge through concrete, problem-solving oriented action. As a result, in the previous fields, our work builds mainly on four methodological streams: multimethodology, design science, action research, and modelling and simulation. This choice of methods is influenced by the researcher-in-residence mode of research that we chose, and the disciplinary roots of this PhD in Industrial Engineering.

The objective in this section is to provide the theoretical background on each method. For each method, we provide theoretical background and the application of the method in healthcare. Section 6 describes how we use them in our research.

5.1. Multimethodology

Theoretical Background

The debate on mixing methods from different paradigms is vivid in many research fields, such as social sciences (Morgan, 2007) or OM (Choi et al., 2016). However, in our case multimethodology refers to a different and more specific concept, developed in the OR community. The early definition of multimethodology is given by Mingers and Brocklesby:

> *"in dealing with the richness of the real world, it is desirable to go beyond using a single (or, on occasions, more than one) methodology to generally combining several methodologies, in whole or in part, and possibly from different paradigms."* (Mingers and Brocklesby, 1997: 489–90)

Multimethodology covers a range of practices going from selecting one method to combining whole-methods on and finally combining parts of methodologies. Besides the approach developed by Mingers and his co-authors, Jackson (2003, 2006) offers an approach to multimethodology based on the principles of "creative holism".

The practice of multimethodology is not straightforward. Mingers and Brocklesby identify three main potential barriers (1997: 496–99):

- Paradigm incommensurability: "The paradigm incommensurability thesis asserts that because paradigms differ in terms of the fundamental assumptions that they bring to organizational inquiry, agents must choose the rules under which they practise from among the various alternatives on offer. They must then commit themselves to a single paradigm, although sequential movement over time from one paradigm to another is permissable."
- Cultural feasibility: "whether agents can learn to operate effectively in two or more paradigms, and move easily between these."
- Cognitive feasibility: "there is prima facie evidence that there is a correspondence between certain 'personality types' and the sort of work that characterizes some of the key management science paradigms."

Although these are important issues, Mingers and Brocklesby conclude to the feasibility and legitimacy of multiparadigm multimethodology. The barriers are later reviewed by Kotiadis and Mingers (2006) in the light of a particular multiparadim-multimethodology project. They conclude that paradigm incommensurability can be handled with adequate strategies, but emphasize on the challenges multiparadigm multimethodology poses to the modeller. The modeller needs to switch from one paradigm to another, and master different methods from different paradigms. Her ability to do so will depend on her past experience and on her personality to a great extent.

Reviews and surveys have shown that the combination of methods has become frequent in practice (Munro and Mingers, 2002) and in academia (Howick and Ackermann, 2011; Pidd, 2012).

Multimethodology in Healthcare

Examples of multimethodology in healthcare are numerous. An early example is a project by Lehaney and Paul (1996) combining SSM and simulation. The coupling of SSM and simulation has been investigated deeper after that (Holm et al., 2013; Holm and Dahl, 2011; Kotiadis, 2007). Other authors have combined simulation with cognitive mapping (Pessôa et al., 2015; Sachdeva et al., 2006) or Lean management (Baril, Gascon, Miller and Cote, 2016).

5.2. Design Science (DS)

In this Sub-section, we first present the origins of the concept of DS. We then show how it has been adapted to management research and OR. Finally, we discuss the application of DS in healthcare.

Origins

DS has its roots in the distinction Herbert Simon made between the natural sciences and the sciences of the artificial (Simon, 2008). The natural sciences take an external posture towards a preexisting world that the researcher tries to understand and model. This is the way research is done in physics or biology. Conversely, "design science is the scientific study and creation of artefacts as they are developed and used by people with the goal of solving practical problems of general interest" (Johannesson and Perjons, 2014: 7).

The distinctive feature of DS is thus the production of artifacts (Johannesson and Perjons, 2014). Rather than studying the world to create explanatory knowledge, in DS, "the researcher is interested in developing "a means to an end", an artifact to solve a problem" (Holmström et al., 2009: 67). Cross explains this notion:

> *"What designers especially know about is the "artificial world"—the human-made world of artifacts. What they especially know how to do is the proposing of additions to and changes to the artificial world. Their knowledge, skills, and values lie in the techniques of the artificial. (Not "the sciences of the artificial.") So design knowledge is of and about the artificial world and how to contribute to the creation and maintenance of that world. Some of it is knowledge inherent in the activity of designing, gained through engaging in and reflecting on that activity."* (Cross, 2001: 54)

Complementary definitions are provided by design engineering researcher Chakrabarty, in the first editorial to the *Design Science Journal* (Chakrabarty, in Papalambros, 2015: 9): "a design is taken here as a plan for intervention which, when implemented, is intended to change an undesirable situation into a (less un-) desirable one. Designing is the process of identifying these situations, as well as of developing designs to support the transition."

In the same contribution, Chakrabarty refines his definition:

- *"Designs are plans for intervention that may include artefacts. Not all designs include artefacts, and not all designs consist of artefacts only.*
- *The concepts of undesirable and desirable situations are essential to the act of designing. Without an undesirable situation, there is no designing.*

- *Designing involves identifying these situations as well as developing the plan with which to change the undesirable into desirable.*
- *It is the implementation of the design, and not the design itself, that actualizes change.*
- *A design is implemented with the hope that it will bring in the desired change, which may or may not happen; hence the need for design science."*

One should note how Chakrabarty considers DS without artefacts. Indeed, Simon himself was taking a very wide perspective on design:

> *"Everyone designs who devise courses of action aimed at changing existing situations into preferred ones. The intellectual activity that produces material artifacts is no different fundamentally from the one that prescribes remedies for a sick patient or the one that devises a new sales plan for a company or a social welfare policy for a state."* (Simon, 2008: 111)

"Courses of action", i.e. plans and methods, can be considered as design artefacts, as noted by Blessing and Chakrabarty (2009). Thus, DS is a pragmatic approach, aiming at solving practical problems through systematic methods. DS produces artefacts to solve problems. DS is the traditional approach of engineers and architects. Engineers and architects use the knowledge from physics, mechanics, chemistry and other natural sciences as well as their disciplinary knowledge on engineering design and architectural design to design artefacts that answer human needs (Blessing and Chakrabarti, 2009). DS also relates to the way clinical research is performed: design a protocol based on existing biological knowledge, try it in a real situation and evaluate its usefulness. Like medicine, DS produces both descriptive and prescriptive knowledge.

DS in Management Research and OR

There have been multiple articles in the past decade on DS and its potential implications for management research of all kinds, in general management (Romme, 2003; van Aken, 2004; van Aken and Romme, 2009), OM (Holmström et al., 2009; van Aken et al., 2016), Information Systems (IS) (Gregor and Hevner, 2013; March and Smith, 1995) and OR (O'Keefe, 2014).

The starting point for all these approaches is a concern about the relevance of academic research to management practice. Some management theorists have posited that this problem is not one of knowledge transfer, but rather one of knowledge creation (Van de Ven and Johnson, 2006). If practical and theoretical really are distinct forms of knowledge, then we as researchers may ask ourselves "whether we are merely observers and evaluators of the practitioners' problem-solving activity or whether we as researchers *become* problem solvers." (Holmström et al., 2009: 66) The answer to this concern was a "design science" stream, based on Herbert Simon's works.

However, management research differs from classic design disciplines like engineering or architecture. The object of management research is organized human activity, not physical artefacts (or software in the case of IS). Therefore the concept of artefact creation would take another form. Artefacts in management DS are formalized as "generic designs" instantiated in "design propositions" (van Aken, 2004; van Aken et al., 2016; van Aken and Romme, 2009). A generic design is a concept, an ideal type. Then, design propositions state that in a given context, to achieve a given goal, a particular generic design is adequate. Generic designs can be compared to Christopher Alexander's *solutions*, while design propositions resemble Alexander's architectural *patterns*:

"Each pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice." (Alexander et al., 1977: x)

"Each solution is stated in such a way that it gives the essential field of relationships needed to solve the problem, but in a very general and abstract way—so that you can solve the problem for yourself, in your own way, by adapting it to your preferences, and the local conditions at the place where you are making it . . . [each solution] contains only those essentials which cannot be avoided if you really want to solve the problem . . . we have tried, in each solution, to capture the invariant property common to all places which succeed in solving the problem" (Alexander et al., 1977: xiii–xiv)

When undertaking design science in management research, one moves away from explanatory research into the realm of exploratory research:

"In explanatory research the phenomenon to be studied already exists out there, and the goal of the researcher is to develop an understanding of it. In exploratory research and design science, in contrast, the phenomenon must be created before it can be evaluated; the creation of artificial phenomena *or simply* artifacts *(e.g., technologies) is essential."* (Holmström et al., 2009: 68)

A recognized example[3] of DS in OM journals is a paper by (Trovinger and Bohn, 2005) where the researchers associate Single Minute Exchange of Dies, a traditional technique from Taichi Ohno's Toyota Production System, to an IT system. SMED is a generic design, which is implemented by means of a dedicated IT system.

The position of OR with regards to this movement is not easy to define. Despite the academic drift, OR was originally a problem-solving discipline, and a large share of OR papers are applied to real companies. However, the implementation of OR tools and techniques in real problem-solving situation and decision-making contexts is still an important issue. O'Keefe (2014) argues that models should be incorporated in IS systems to provide routine decision support, rather than one-shot analysis. We take a wider perspective and also argue for the definition of methods and procedures that can assist individuals in their problem-solving efforts. Thus, we follow Romme's perspective, detailed when he identifies three generation of design methodologies in management research (2003: 564–5):

- The first generation is the "scientific management" movement led by Frederick W. Taylor. "The core of these approaches involved specific schemes and practices for improving managerial control and coordination".
- The second generation includes Peter Checkland's SSM and the sociotechnical systems approach of Emery and Trist. Compared to their predecessors, these authors "described and codified general processes rather than specific tools and practices."
- The third generation is "characterized by a co-evolutionary, value-laden, and ethics-based systems approach", of which Vennix's group model-building approach (1996) is an example.

3 e.g. by DS in OM theorists van Aken et al. (2016) and Holmström et al. (2009)

DS in Healthcare

Although often not explicitly described as DS under the formalism defined by van Aken et al. (2016), a wide literature in HSR could qualify as DS. For instance, reports of quality improvements projects, which start from an organizational problem, design a solution, implement it, and evaluate this implementation, can be regarded as DS. A first example is the design of a software based on the Analytic Hierarchical Process for the planning of chemotherapy production (Bonan et al., 2010; Vidal et al., 2010). The artefact is a software, which the authors evaluate in a specific context. Other works have looked at the impact of telehealth. In this case the artefact is a telehealth system, composed of some software and a set of methods and processes to guide the way it is to be used. The system is designed to address to a wide array of challenges (cost of transportation, geographical inequalities in access to care). Authors have evaluated it against the expectations of involved stakeholders (Duong, 2016; Jean, 2013).

Regarding DS in healthcare management research, van Aken et al. (2016) point to the works of Senot et al. (2016), who describe an intervention to facilitate physician-nurse collaboration. They identify a problem in physician-nurse collaboration that impacts on the delivery of care, and propose and evaluate a solution concept based on “physician-led cross-level collaboration” and “nurse-led cross-level collaboration”, whereby representatives of one professional category from a higher hierarchical level discuss changes with frontline workers of the other category. More widely, the “improvement science” (Berwick, 2008) and “evidence-based management” (Walshe and Rundall, 2001) streams in healthcare could also be related to DS as they consist in developing and evaluating interventions aimed at solving problems in healthcare delivery.

5.3. Action Research (AR)

In this Sub-section, we first present the origins of AR and its originality compared to the traditional scientific method. We then further describe AR as research through action. Third, we discuss the different types of AR. Fourth, as the two methods may seem close, we precise the distinctions between AR and DS. Finally, we discuss the application of AR in healthcare.

Origins and Originality

Action research is generally dated back to the works of Kurt Lewin (Lewin, 1946, 1947) on change management and group dynamics. Lewin identified two types of questions in social research: “the study of general laws of group life and the diagnosis of a specific situation” (1946: 36). His concern was at the interface of these two domains, in the integration of abstract, general laws and concrete, specific situations. He proposed to complement the dominant method of survey research with a new approach where researchers would immerge themselves in situations of social change. His 1947 paper clearly details the systemic perspective he thought was needed in social research to account for social interactions (1947: 8).

Lewin’s method went against the prevalent mode of doing research. According to Checkland and Holwell (1998: 10), “The scientific method can be expressed as being based on three fundamental principles which characterize it and give it its power: reductionism, repeatability, and refutation”. On the opposite, AR is systemic/holistic, intrinsically unrepeatable (the real world does not repeat itself like in controlled experiments), and AR is not a hypothesis-testing methodology.

To answer to regular criticisms against the validity of AR, Susman and Evered (1978) build a compelling argument, by reconsidering the positivist perspective as the only one valid in science. They identify philosophical viewpoints which contribute to legitimate AR as a valid scientific method and an alternative to positivist science. Later, Eden and Huxham (1996) defined standards for good AR (which they immediately declared to be probably impossible to meet all at once in practice). Checkland and Holwell (1998) and McKay and Marshall (2001) provide complementary discussions on research quality in AR.

Action {and} Research: the Dual AR Cycle

Lewin was most concerned with group dynamics, but since then, AR has extended to other subjects of enquiry, including more personal versions focused on reflexive thinking. The common ground between all these AR approaches is summarized by Coughlan and Coghlan:

> "*Several broad characteristics define AR:*
>
> - *research in action, rather than research about action;*
> - *participative;*
> - *concurrent with action;*
> - *a sequence of events and an approach to problem solving."* (2002: 222)

Another agreed point is that AR is cyclic, although the number of steps in the cycle and their labelling may vary:

- three steps—look, think, act—for Stringer (2014);
- four steps—diagnosing, planning action, taking action, evaluating action—for Coghlan and Brannick (2014);
- five steps—diagnosing, action planning, action taking, evaluating, specifying learning—supported by the development of a client-system infrastructure for Susman and Evered (1978).

We find the AR cycle described in most detail by Coughlan and Coghlan (Figure 4):

> *"The AR cycle comprises three types of step . . . :*
>
> *(1) a pre-step – to understand context and purpose;*
> *(2) six main steps – to gather, feed back and analyze data, and to plan, implement and evaluate action;*
> *(3) a meta-step to monitor."* (Coughlan and Coghlan, 2002: 230)

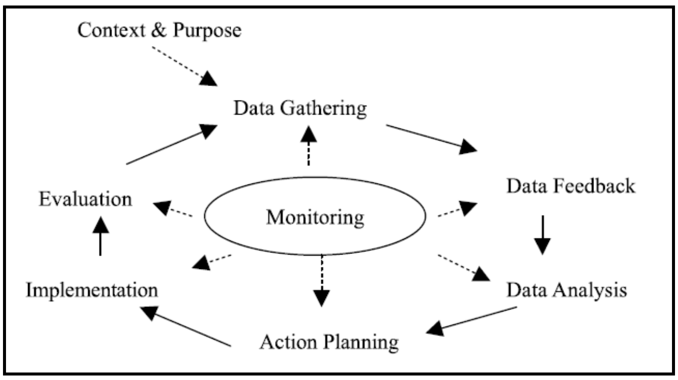


Figure 4 - AR cycle (Coughlan and Coghlan, 2002: 230)

This definition makes clear the “dual imperative of AR” (McKay and Marshall, 2001): solving practical problems, while generating and testing theory. The “six main steps” are a problem-solving cycle, while the monitoring meta-step constitutes the position of the researcher. McKay and Marshall go further and define a double-cycle for AR: one cycle for the problem-solving dimensions (Figure 5a), and one for the research dimensions (Figure 5b).

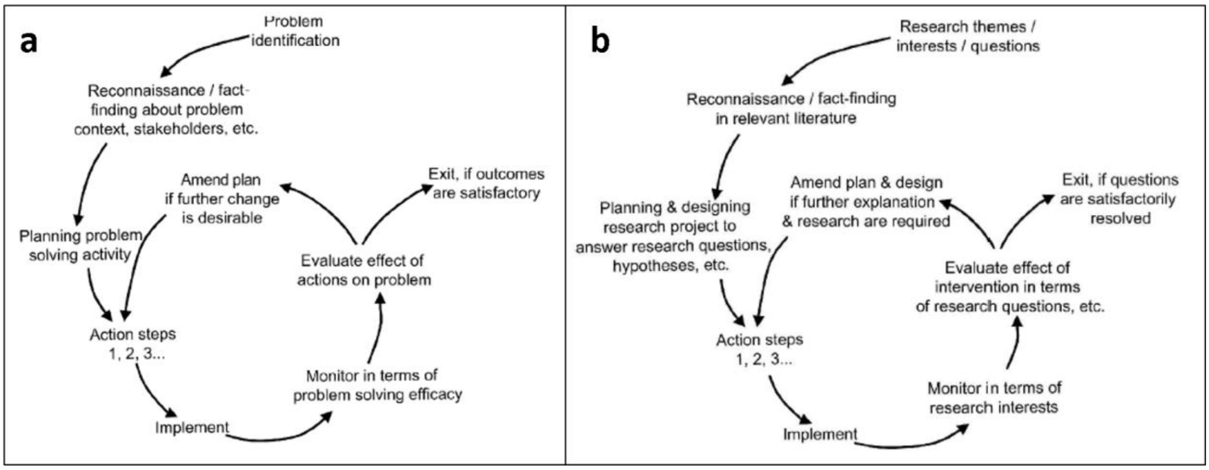


Figure 5 - Problem-solving cycle (a) and research cycle (b) in AR (McKay and Marshall, 2001: 50–1)

These two cycles are connected into a dual cycle of AR (Figure 6).

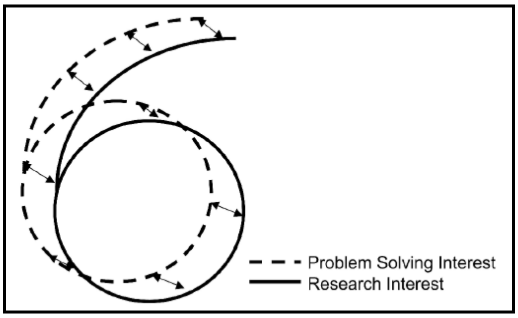


Figure 6 - Dual cycle of AR (McKay and Marshall, 2001: 52)

An AR project can then be defined with five parameters: its theoretical Framework *F*, its Research Methodology M_R, its Problem-Solving Methodology M_{PS}, its theoretical Area of interest *A* and its practical Problem situation *P* (McKay and Marshall, 2001: 56).

Types of AR

Different streams exist in AR (Coghlan and Brannick, 2014: 13–20). Some focus heavily on reflexive learning from the researcher, e.g. when in their textbook McNiff and Whitehead write that in AR “the object of the enquiry is the ‘I’ ” (2006: 26). In our case, to quote Huxham (2003: 240), we are “not concerned here with varieties that are principally forms of self-development or organisational development . . . The promotion of ideological positions about participation and empowerment . . . is also not an essential aspect of [our] approach”.

The type of AR we are interested in in this dissertation is the one practiced by Peter Checkland to develop SSM (Checkland, 1981). Through interventions in an organization, using somehow formalized methods (or in our case, combinations of methods), the researcher generates learning on both the nature of the organization and the performance of the problem-solving methods.

AR and DS

A distinction must be made between design science and action research (AR). The debate has emerged on this topic in the IS research community (Iivari and Venable, 2009; Järvinen, 2007), and it needs to be clarified here.

Coughlan and Coghlan (2002: 222) define AR as "research *in* action, rather than research *about* action; participative; concurrent with action; a sequence of events and an approach to problem solving". It is clear that AR and DS share some characteristics. AR is a pragmatic, problem-oriented approach. AR works under the principle that to know more about a system, one should try to change it. This is what DS does when an artefact is introduced in an organizational setting and its impact on the organization's performance is evaluated. Analyzing characteristics of AR and DS, Järvinen (2007) concludes that AR and DS are similar in IS research.

However, if DS and AR may overlap, not all AR is DS and conversely. In particular, AR studies that focus on reflective and reflexive thinking from the researcher, without the production of a specific artifact (a type of AR particularly emphasized by Stringer (2014) and Mc Niff and Whitehead (2006) for instance), cannot qualify as DS (Holmström et al., 2009). Romme (2003: 564) adds that "Design research incorporates several key ideas from action research, but is also fundamentally different in its future-oriented focus on solution finding".

Moreover, not all DS is AR: DS is the main approach for mechanical engineering researchers, but they do not use AR much, as organizations are usually not their prime research object (mechanical engineers may evaluate and test products with users, but this approach is essentially different from AR as product users do not agree to the constraints of an organization the same way employees or organization members do). Iivari and Venable (2009) also identify epistemological and ontological differences between DS and AR. They conclude by defining AR as a research method and DS as a research orientation for which various research methods are valid, in particular AR for evaluation. However, they argue that DS does not need to be participatory.

On this last point, the advantage of co-design has been underlined in the design literature (Marc Steen et al., 2011). The argument has also been given in management research that coproduction of knowledge (Van de Ven and Johnson, 2006) and AR for DS (Holmström et al., 2009) are important opportunities. Therefore, although AR and DS are not similar, their combination is promising.

AR in Healthcare

AR is widely used in healthcare settings. Montgomery et al. (2015) review AR projects in hospitals. With a focus on management issues, a recent example is Waring and Alexander's project on patient flow management (Waring and Alexander, 2015). This article is interesting as it very clearly illustrates the two dimensions of AR:

- In practice, the researchers contributed to the implementation of a new patient flow management system in the hospital. In this regard, their study could have been framed as a DS study, with the software as the artefact.
- The theory they generated was on the diffusion of process innovation in complex, political healthcare organizations. This was conditioned by their theoretical frame, the Diffusion of Innovation theory.

5.4. Modelling and Simulation (M&S)

The last research method we present is Modelling and Simulation. We first provide some definitions of M&S. We then discuss the application of M&S in healthcare.

Definitions

Models are almost everywhere in science. In this section, we will limit ourselves to the way they are defined and used in OR, OM, and management sciences in general. Modelling is a purposeful activity, and we focus on models that are developed in order to support decisions waiting to be made, rather than on models developed to understand better the way a real phenomenon occurs.

Many definitions of what a model is co-exist. In the domain of management sciences, we choose the definition provided by Schwaninger:

> *"By model, we understand the representation of a real system. More exactly, a model is an abstract, conceptual system by which a concrete system is represented. Models can both reproduce or re-create (→ "portrait"), and anticipate (→ "paragon"). They may refer to either actual or potential ("ideal") systems, and they can be either formal or informal. A formal model is cast in a stringently logical and mostly mathematical way, e.g. a simulation model, a balance sheet or an architectural plan. Informal models, if explicit, use fuzzier or abridged modes of expression."* (Schwaninger, 2010: 1420)

The distinction between formal and informal models can be compared to that between qualitative and quantitative models. Quantitative models use mathematics as a way of representing the world. In this category, we find queuing models, discrete-event simulation models, or linear programming models. Qualitative models may use different methods, but a recurrent example is the various forms of "boxes and arrows" models, such as the Structured Analysis and Design Technique (Ross, 1977) for instance. As for simulation, which is a specific type of quantitative modelling, we keep Robinson's definition:

> *"Experimentation with a simplified imitation (on a computer) of an operations system as it progresses through time, for the purpose of better understanding and/or improving that system."* (Robinson, 2004: 4)

Schwaninger details the roles of modelling and simulation:

> *"Modelling and simulation are devices that help their users to understand the systems they are dealing with. The use of models can fulfill different functions, such as description, explanation, design, decision and change. Descriptive models represent what is the case; they make the issue under study comprehensible. Explanatory models elucidate why the real system at hand behaves as it does and not differently. They try to capture interrelationships, e.g. causalities, interactions and dependencies. Models of analysis and diagnosis, which are among the explanatory models, inquire into the implications of system behavior and of the structure underlying it.*
>
> *Design models are instruments that support the conceptual development of systems. Decision models, which can be considered a kind of design model, support decision-making processes. They serve the eliciting of options and their comparative assessment, marking the difference between "better" and "worse" variants, mainly by exploring their consequences and implications.*

In general, models can trigger the discovery of new perspectives and the gaining of insights. They can support the ascertainment and assessment of options, highlight priorities, illuminate uncertainties, and unveil the dynamic features, propensities, risks, and vulnerabilities of a system. They are very helpful in disciplining the organizational discourse." (Schwaninger, 2010: 1421)

Given the complexity of healthcare organizations, models have been widely used for all five functions they serve according to Schwaninger (description, explanation, design, decision and change).

M&S in Healthcare

Brailsford et al. (2009) reviewed the literature on modelling in healthcare. A lot of articles exist on this subject: they counted 176,320. Although statistical approaches are preponderant, simulation and qualitative methods are becoming more and more popular, and given the choice of keywords *((health-care OR healthcare) AND (modelling OR modelling OR simulat*OR (system AND dynamic*) OR markov*)*, it is likely that much more qualitative modelling studies have gone unnoticed in this review. Brailsford et al. use the categories described in Table 1 to classify models used in healthcare. The figures in the two last columns of the table refer to the number of occurrence of a given method in a sample of 342 papers.

Table 1 - Types of models used in healthcare M&S (Brailsford, Harper, et al., 2009)

Category	Sub-category	Primary method	Subsidiary method
Qualitative modelling	Cognitive modelling	3	1
	Process mapping	6	14
Statistical analysis	Regression analysis	77	24
Statistical modelling	Markov models	19	9
	Structural equation modelling	11	1
Simulation	Discrete event simulation	31	6
	System dynamics	6	0
	Monte Carlo simulation	4	20
Spatial modelling	Spatial mapping	5	2

This first review is interesting, as it provides a quantitative insight into the use of each method. One can notice the high prevalence of regression analysis, discrete event simulation, and to a lesser extent Markov models. However, Brailsford et al. do not really account for the variety of qualitative modelling methods. They only include two: process mapping and cognitive modelling. Yet both of these basic approaches have been included in a variety of methods and under different formats.

Another classification that further details the qualitative modelling methods used in healthcare has been proposed by Jun et al. (2011) and is reproduced in Table 2. Even this wider review is not complete, as the category of Problem structuring methods could have included the Viable System Model (Beer, 1985) which is usually included in this category (Jackson, 2003; Mingers and Rosenhead, 2004) and is a modelling approach. Moreover, methods can be combined, for instance Soft Systems Methodology uses activity diagrams.

Table 2 - Tools for healthcare modelling and simulation (Jun et al., 2011)

Categories	#	Methods
Problem structuring methods	**1**	**Drama Theory & Confrontation Analysis**
	2	**Robustness Analysis**
	3	**Soft Systems Methodology**
	4	**Strategic Choice Approach**
	5	**Strategic Options Development and Analysis**
Conceptual modelling methods	**6**	**Activity Diagrams**
	7	**Communication Diagrams**
	8	**Data Flow Diagrams**
	9	**Influence Diagrams**
	10	**Information Diagrams**
	11	**Issue Maps**
	12	**State Transition Diagrams**
	13	**Swim Lane Activity Diagrams**
Mathematical modelling methods	**14**	**Decision trees**
	15	**Markov modelling**
	16	**Multivariate analysis**
	17	**Optimization methods**
	18	**Petri nets**
	19	**Queuing theory**
	20	**Survival analysis**
Simulation methods	**21**	**Agent based simulation**
	22	**Discrete event simulation**
	23	**Gaming simulation**
	24	**Hybrid simulation**
	25	**Inverse simulation**
	26	**Monte Carlo simulation**
	27	**Real time simulation**
	28	**System dynamics**

Given the diversity of methods and the sheer number of publications applying M&S in healthcare, it is illusory to imagine a complete review and classification of approaches used. It is beyond the scope of this dissertation to detail further all these methods, or to comment further on the way they should be classified. In our work, we use problem structuring methods (Soft Systems Methodology and the Viable System Model), activity diagrams, and Discrete Event Simulation. We also use System Dynamics, but in its qualitative form, without developing a quantitative simulation.

Most of these methods were developed outside the healthcare sector. Given this external origin, and with so many methods available, it is important to provide proofs of their applicability in the healthcare sector, and to show to which types of problems they can be applied. Besides, given the complexity of the healthcare sector, it is likely that one method will not be enough in many situations. Therefore the combination of methods should be investigated, so that the strengths of each can compensate for the weaknesses of the others.

6. Our Approach

We have described research fields and methodologies that are relevant to our work. In this section, we describe how we relate to them. We describe our general approach in this PhD, which integrates elements from the fields and methodologies described above.

6.1. A Systemic Perspective

The research described in this dissertation has definitely been influenced by complexity thinking and the complex systems perspective. This shows both in the object of enquiry, and in the research approach.

Our main research object is coordination in hospitals. We always consider hospitals as sets of interconnected activities, individuals, processes and organizational units. This open-system perspective, where relations between entities inside the system and with outside entities are fundamental to understand the behavior of the system, is evidence of our debt to the systems movements.

We also refer to diverse disciplines and research streams. OR, OM and management research are the main domains we explored, but nursing studies and various subfields of HSR have also fed our thinking. From these domains, methods have been combined, hoping to identify synergies between them. Morin's *complex thinking* (1990) was inspirational in this approach.

6.2. OR Methods

We use M&S for interventions in organizations (both to structure the intervention and as an intervention medium) and as a means to explore, explain and transfer knowledge about the way they work. Our M&S toolkit mainly comprises OR methods, from both Hard and Soft OR: the Viable System Model, Soft Systems Methodology, Discrete Event Simulation and qualitative System Dynamics. In addition, two methods from marketing research (benchmarking and service blueprinting), one from change management (the 8 steps for leading change) and one mainly from engineering (structural analysis) are used.

We combine these methods under the principles of multimethodology. Regarding our paradigmatic positioning, we build mainly on two paradigms: structuralist-functionalist, and interpretive.

6.3. A Design Science Approach Involving Action Research

This research is structured around an AR project at Henri Mondor hospital in 2015-2016. The perspective taken during this work is that of management engineering, although not necessarily with the functionalist flavor that this expression may convey. The roles of management engineers "are to identify industrial problems that cannot be readily solved with the current methodological toolkit." (Guide and Van Wassenhove, 2007: 533) In the end, we aim at defining methods for tackling practical concerns of hospital professionals. This has been possible in chapters II and III. The descriptive explanatory study in chapter IV is hopefully a first step in a problem-solving endeavor about strategizing in public academic hospitals.

Consequently, the approach can be described as DS, although only some of the results have been formally transcribed as DS research, in chapter III. Combining and adapting methods tested in other fields, we hope to solve some of the problems hospital managers face, which is a type of DS research called *exaptation*, adapting an artefact developed in one context to a different one (Johannesson and Perjons, 2014), and a form of contingency research (Sousa and Voss, 2008).

6.4. A Field of Application: Healthcare OM

The field of this research is mainly OM. In chapters I, II and III, we look at core production processes. Although in chapter IV we move to strategic issues, it could be argued that our strategic perspective mainly focuses on hospital operations, since we do not discuss strategic issues in HR, finances or IS. It could be labelled "operations strategy", "the pattern of strategic decisions and actions which set the role, objectives and activities of the operation." (Slack et al., 2009: 63)

To summarize, our objective is to define, adapt or combine methods to generate improvement in efficiency in hospital operations. A specific emphasis is put on sources of complexity: interdepartmental coordination, and political or power relationships. Therefore, we take special interest in the coordination perspective.

The methods we use come from OR/OM. To ensure their efficiency, we test them in real conditions, using action-research and design science as our principal research methods whenever possible. The case study in this work is outpatient chemotherapy, but we seek wide applicability.

7. Structure of the Manuscript

This dissertation is structured as a collection of essays, all of which have been, or are about to be, submitted to peer-reviewed journals. In an academic world where the publish-or-perish paradigm seems to be here to stay, we thought it would be best to live by the efficiency principles we try to have others enforce, and focus on the most impacting type of publication: peer-reviewed journal articles. This choice has a downside: although we reworked the papers to reduce repetitions as much as possible, a certain level of repetition is bound to appear. We ask for the reader's understanding on this point. To ease the reading, all references have been gathered at the end of the dissertation.

We now present the way the contents of this dissertation map the research questions presented in Section 3 of this Introduction. We then provide a brief summary of each chapter.

7.1. Research Framework

There are two ways of considering the research presented in this dissertation: in relation to its research questions, or in relation to the intervention at Henri Mondor hospital, in a more chronological fashion.

Research Questions

In Section 3, we formulated three research questions for this work. They are treated in the four chapters of this dissertation as presented in Figure 7.

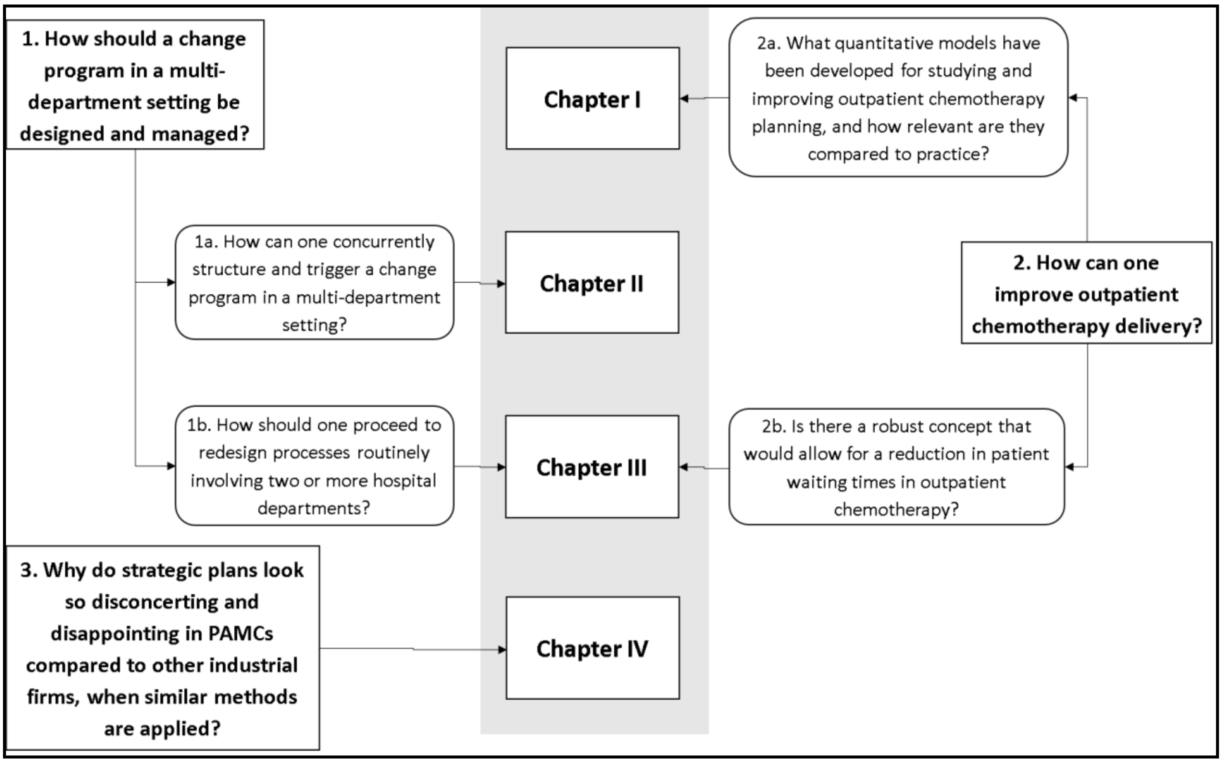


Figure 7 - Relations between research questions and the chapters of this dissertation

Chronological View

Another way to look at this dissertation and its chapters is to take a chronological perspective and consider the chapters in relation with the intervention at Henri Mondor hospital. This alterative view is presented in Figure 8. Our work started with the initial demand of the head of the oncology unit. We then proceeded to a literature review and a problem structuring, using the Viable System Model. This first stage produced two main outputs: the literature review in Chapter I, and the change program and change management approach in Chapter II.

Part of this change program was to redesign the process for outpatient chemotherapy delivery, in order to increase the coordination between the departments involved this process. This is the process redesign project on Figure 8, which led to a new process, and the design method presented in Chapter III.

The change program also involved a more long-term perspective, to try to assess the future activity in the cancer division. This took the form of a scenario-building project, which is not finished in practice but was the source of the research presented in Chapter IV, for which it also provided empirical content.

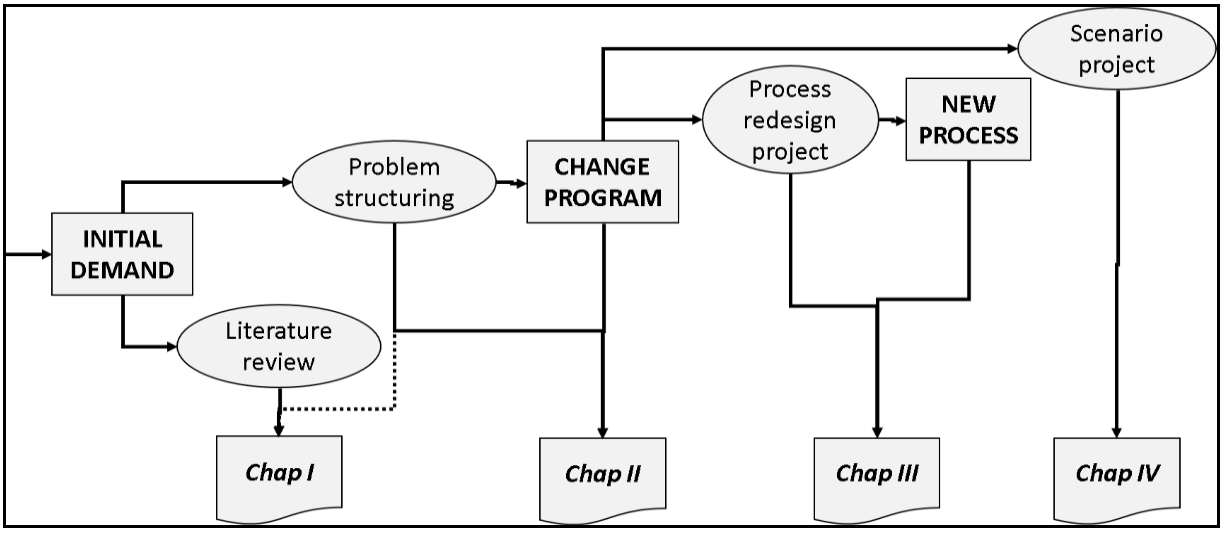


Figure 8 - Alternative view of the dissertation and its relation to the intervention at Henri Mondor hospital

We now briefly summarize the four chapters that constitute the main body of this dissertation.

7.2. Brief Summary of the Essays

Chapter I

In this chapter, we review the contributions in the operations management and operations research (OM/OR) literature that address the planning of outpatient chemotherapy, one of the main treatments for cancer. The distinctive characteristics of outpatient chemotherapy are highlighted. In particular, the interdependence between the administration of chemotherapy drugs in the outpatient clinic and drug preparation in the pharmacy is pointed out. This makes outpatient chemotherapy planning a multiple department challenge where coordination is essential to the global performance of the system. The modelling challenges induced by this interdependence and by the clinical dimension of chemotherapy are presented. Finally, a case study is performed to confront the literature with the reality of a hospital. Important gaps in the literature are outlined, such as the lack of studies taking an integrated, systemic perspective on this multi-department issue.

Chapter II

In this chapter, we present the results of an action-research project in Henri Mondor hospital. We combine the Viable System Model (VSM) and Kotter's 8 steps for leading change to initiate a change program aimed at integrating the processes needed for outpatient chemotherapy in this hospital. The VSM allows the diagnosis of the existing organization, and the elaboration of a working plan. The plan is concurrently implemented using Kotter's 8 steps. The analysis of this projects yields two contributions. The first one is methodological, on the problem-solving approach we used. The VSM is powerful when embedded in a change management process, and Kotter's 8 steps fit well to initiate change. The second contribution is on the factors promoting or impeding integration, and is based on experiential learning during this project. We contribute add to existing knowledge by identifying these factors and propose an update of existing models in the light of our case study.

Chapter III

In this chapter, we propose an original approach mixing four methods in order to tackle multidepartment coordination issues in hospitals. The novelty of our approach comes: (i) from the integrative view it takes of the two departments, their interests and their interdependencies; and (ii) from the comprehensive view on the problem solving process. The approach is developed and tested during an action-research project on outpatient chemotherapy delivery in Henri Mondor hospital. Outpatient chemotherapy involves two departments: the outpatient oncology unit, and the pharmacy. The former wishes to minimize patient's waiting times, while the latter needs to minimize the cost of wasted chemotherapy drugs. We take into account the fact that globally optimal solutions may not be satisfactory because of the way accounting and reporting is split across separate units. We also propose a method that mixes the computational power of simulation, with participative methods that allow for the expression of ideas, interests and the negotiation of solutions. Rather than focusing solely on problem framing before simulation, we also support the later stages, once a concept has been chosen with simulation and must be developed into an operational business process. The theory generated is formulated as two design propositions.

Chapter IV

Public Academic Medical Centers (PAMCs) have long been described as complex organizations. This is presented as the reason why strategic planning often fails in PAMCs. Yet this complexity has not been qualified. This is what this article aims at, using systemic modelling. Our data is based on empirical work in a French PAMC, and on regulatory constraints in French PAMCs. We propose a qualitative system dynamics model of hospital operations, and a dependency structure model of PAMC governance. Thanks to these models, we identify two main challenges for PAMC strategic planning. They stem from the uncertainty on patient's hospital choice determinants, and from the multipolar nature of the governance system, which we detail. These findings open perspectives for systems analysis and modelling in PAMC to support strategizing.

The dissertation ends with a general discussion which addresses the theoretical and managerial implications of this work, the limits of our research approaches, and the perspectives it opens for future research.

I. Outpatient Chemotherapy: A Literature Review with Insights from a Case Study[4]

In this chapter, we review the contributions in the operations management and operations research (OM/OR) literature that address the planning of outpatient chemotherapy, one of the main treatments for cancer. The distinctive characteristics of outpatient chemotherapy are highlighted. In particular, the interdependence between the administration of chemotherapy drugs in the outpatient clinic and drug preparation in the pharmacy is pointed out. This makes outpatient chemotherapy planning a multiple department challenge where coordination is essential to the global performance of the system. The modelling challenges induced by this interdependence and by the clinical dimension of chemotherapy are presented. Finally, a case study is performed to confront the literature with the reality of a hospital. Important gaps in the literature are outlined, such as the lack of studies taking an integrated, systemic perspective on this multi-department issue.

[4] Published as: Lamé G, Jouini O and Stal-Le Cardinal J (2016) Outpatient chemotherapy planning: A literature review with insights from a case study. *IIE Transactions on Healthcare Systems Engineering* 6(3): 127–139.

1. Introduction

From the point-of-view of OM/OR, outpatient chemotherapy shows a number of particularities. Many studies have been published on outpatient scheduling (Cayirli and Veral, 2003) and hospital patient flows (Bhattacharjee and Ray, 2014). However, outpatient chemotherapy is somehow in-between. It is not a simple consultation: the patient receives a treatment which may last as long as six hours. This treatment has to be prepared in the pharmacy. Therefore, outpatient chemotherapy requires the coordination of different services inside the hospital to provide the right treatment to the right patient while minimizing the costs and the patient's waiting time. Outpatient chemotherapy is also different from outpatient surgery: patients require intermittent attention from medical staff, which makes it a coupled operations issue when it comes to planning. Finally, the presence of target dates for appointment planning, and the limited tolerances regarding their respect is another distinctive characteristic of outpatient chemotherapy. To the best of the authors' knowledge, no review exists on outpatient chemotherapy planning. Yet, the rising number of articles shows that this subject is gaining momentum. In this paper, we describe and discuss the distinctive features of outpatient chemotherapy planning studied in the OM/OR literature.

The orientation is towards application and implementation of OM/OR models and recommendations in practice, which is an important challenge in healthcare OM/OR studies (Brailsford and Vissers, 2011; Proudlove et al., 2007). The literature is thus reviewed and synthesized from this angle. To go further and to put the literature into perspective, a case study is also introduced. The objective is to assess how the literature covers different organizational structures and takes into account the associated challenges. The situation of Henri Mondor hospital is presented. This case study illustrates that relationships and interdependences between departments are insufficiently addressed in the literature. For instance, more attention needs to be paid to the interdependence between the pharmacy and the outpatient clinic. In the literature, most articles study integrated cancer care centers, and only one paper describes a hospital with a centralized pharmacy from a systemic perspective, encompassing both the pharmacy and the outpatient clinic. However, we show that the case of general hospitals with centralized pharmacies justifies specific studies because of the close relation between the two departments. This case is representative of many European hospitals. The discussion highlights areas for future research on outpatient chemotherapy as a multi-department system and underlines the insufficient knowledge available on patient satisfaction predictors.

The rest of the chapter is organized as follows. In Section 2, the method for identifying relevant articles is presented. Section 3 provides an overview of the clinical side of chemotherapy and the care process. Section 4 covers the organizational characteristics of outpatient chemotherapy. Section 5 deals with modelling issues. Three specific sources of complexity are developed: the coupled operations issues, the tolerances for treatment planning and the uncertainty on patients' status. In Section 6, a case-study is presented which serves as a basis for discussing the literature and confronting existing papers to current hospital practice. Section 7 discusses new directions for research. The chapter ends with some concluding remarks.

2. Literature Review Procedure

To identify relevant articles, the *Web of Science* database was searched with the following combination of keywords: (*outpatient* OR *ambulatory* OR *pharmacy*) AND (*oncology* OR *chemotherapy* OR *cancer*) AND (*plan** OR *schedul** OR *simulat** OR *optimiz**). This first step generated 3,587 results. Keeping only articles in English reduced the number of results to 2,918 articles. Research areas were then refined to keep only *Operations Research & Management Science* and *Healthcare Sciences & Services*. The resulting list contained 1,215 articles. The authors read the 1,215 titles and abstracts with the following criteria:

- Keep only articles which address chemotherapy administration (and not only medical consultations in oncology, which is similar to appointment scheduling, e.g. (Santibáñez et al., 2009)).
- Keep only articles that include at least one quantitative OR model for decision support (even when the quantitative model is used in combination with other, qualitative, techniques, e.g. (Baril, Gascon, Miller and Cote, 2016)). Therefore a paper such as (Baril, Gascon, Miller and Bounhol, 2016), where a case study on outpatient chemotherapy illustrates a methodological proposition on combining work sampling and simulation to obtain more realistic simulation models, is excluded as no operational objective is presented.
- An exception is made when the implementation of a quantitative OR model is developed in a separate paper (Kergosien et al., 2011; Mazier et al., 2010), or when a "qualitative" article describes a complementary part of an OR/OM intervention, e.g. (Masselink et al., 2012; van Lent et al., 2009).

This process resulted in a set of 11 articles. The references cited in these 11 articles were analyzed. In addition, articles citing these 11 articles were also screened, using *Google Scholar* and the *Web of Science*. 14 additional articles were included thereafter. As a result, 25 relevant papers are referenced in this review.

3. Background: Introduction to Outpatient Chemotherapy

Before moving to operations management issues of outpatient chemotherapy, we briefly describe in this section some clinical aspects of chemotherapy regimens. We also provide some elements on its standard care process.

3.1. Clinical Elements on Chemotherapy Regimens and Cures

Various types of treatment are possible against cancer. In chemotherapy, a drug or a combination of drugs is used to attack cancer cells. Chemotherapy administration is organized based on a chemotherapy regimen. A chemotherapy regimen is a set of cures. In each cure, a combination of drugs is administered to the patient by injection or intravenous (IV) infusion. Then, there is no intervention for a specified amount of time, after which a second cure is administered. Examples are provided for stage III colon cancer (Schmoll et al., 2006):

Regimen 1 (XELOX):

3-week cycle: Day 1: oxaliplatin 130 mg/m² 2-hour IV infusion

Day 1 to 14: oral capecitabine 1000 mg/m² day 1 to 14

Repeat for 8 cycles (24 weeks total treatment)

Regimen 2 (Mayo Clinic regimen):

4-week cycle: Day 1 to 5: leucovorin 20 mg/m² rapid IV infusion and then FU 425 mg/m² IV bolus

Repeat for 6 cycles (24 weeks total treatment)

Regimen 3 (Roswell Park regimen):

8-week cycle: Day 1 of weeks 1 to 6: leucovorin 500 mg/m² 2-hour IV infusion then FU 500 mg/m² IV bolus

Repeat for 4 cycles (32 weeks total treatment).

In Regimen 1, the patient will come to the hospital every three weeks to receive oxaliplatine in a 2-hour IV infusion. She will then take oral capecitabine, which does not require her to come to the hospital, for 14 days. She will then have a break for a week, and start again with oxaliplatine. This cycle is repeated eight times. At the end of the cycles, the efficiency of the treatment is assessed, and a new regimen can be decided. The state of the patient is also monitored between cures as chemotherapy can have severe side-effects.

These three examples show that chemotherapy regimens vary in terms of total duration, cycle duration, administration mode (oral, IV infusion, IV bolus – injection), infusion duration, etc. For all treatments, the prescriptions must be rigorously followed. The objective is to deliver the right dose with the appropriate intensity (dose per unit of time) so that the tumor is effectively attacked. Higher doses lead to better response rates (Frei and Canellos, 1980), and lower dose intensity decreases treatment effectiveness (Lyman, 2009).

3.2. Standard Care Process Organization

Chemotherapy administration (injection, infusion or oral administration) is only one part of the organization of chemotherapy. Other elements need to be taken into consideration: (i) consultations, blood tests and drug preparation; (ii) the involved capacity in terms of human and technical resources. These two elements are described next.

Process

Figure 9 lays down the steps of the patient pathway for a chemotherapy session. It shows that blood tests are performed before each session in order to ensure that the treatment can be safely administered. The blood test results are reviewed and the patient is examined by an oncologist. If the patient’s condition is adequate, the oncologist prescribes the drugs. This prescription is thereafter transmitted to the pharmacy which can start preparing the drugs.

However, all the steps of the process are not performed each time a patient comes to the outpatient department. Some patients don’t need blood tests on a specific day, e.g. because they come for several consecutive days. For the same reasons, some patients don’t get an oncologist appointment and go directly to chemotherapy administration. Liang et al. (2015) distinguish three categories: OC –

oncologist appointment and chemotherapy, O – oncologist only, C – chemotherapy only. An additional distinction can be made on whether the patient requires a blood test or not, resulting then in 6 categories: OC, BOC, O, BO, C, BC. This classification is shown on Figure 9.

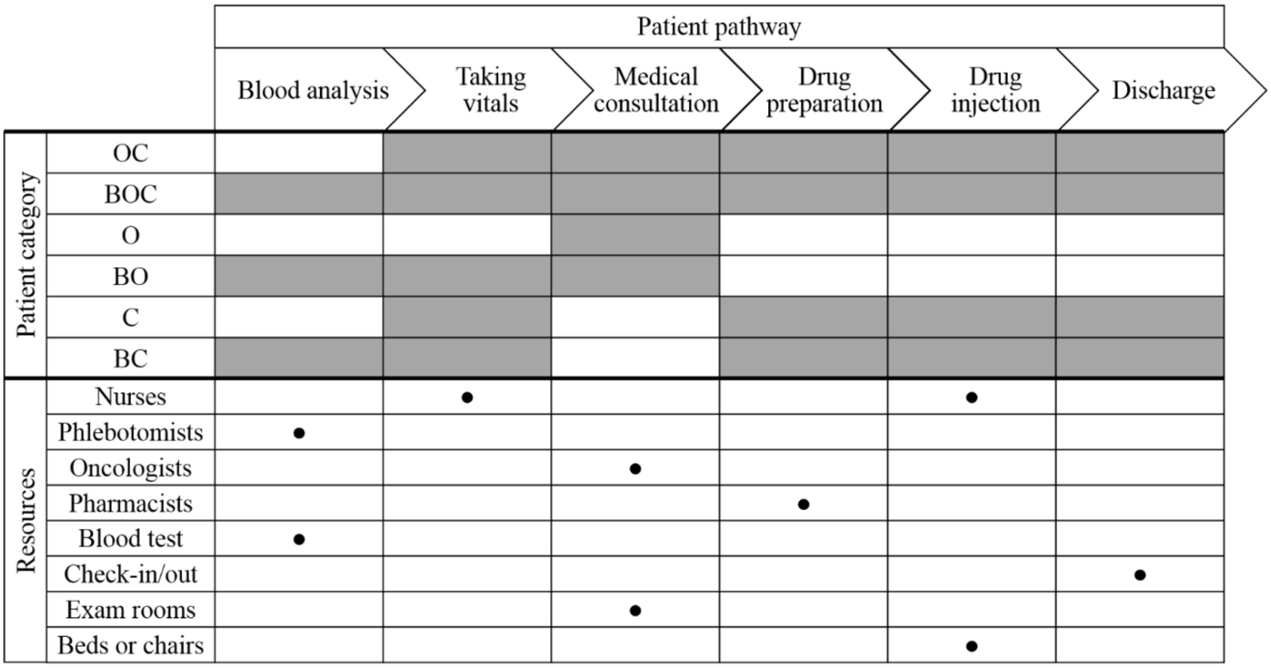


Figure 9 - Patient pathway for outpatient chemotherapy with patient categories and resources

Resources

To perform the activities of the care process, the following resources are considered in the literature: nurses, phlebotomists, oncologists, pharmacists, blood test capacity, check-in/out receptionists, exam rooms and beds or chairs. Nurses usually perform a wide range of activities. They welcome the patient, take her vitals, draw blood samples, set up the intravenous infusion and follow-up on the patient during the infusion. They also perform indirect tasks like scheduling patients (Baril, Gascon, Miller and Bounhol, 2016; Blay et al., 2002). Phlebotomists are responsible for drawing blood samples (although this is sometimes done by nurses). Oncologists consult with the patient before the actual drug administration and they are responsible for drug prescription. Depending on their status, they may also have teaching and research activities. Oncologists could be further subcategorized as “full” doctors or interns. Pharmacists and their assistants are responsible for mixing chemotherapy drugs. They work in a subsystem, the pharmacy, where drug preparation is planned and performed. Blood test capacity represents the lab’s capacity to process blood samples. The lab can be either dedicated to the chemotherapy department or a general lab for the hospital. Check-in and check-out receptionists welcome patients and see them before they go home. They don’t perform medical tasks. Exam rooms are for doctors to consult with their patients. Beds or chairs are for chemotherapy administration: each patient needs one during drug injection. Figure 9 maps the involved resources for the various process steps. Although the process steps and resources are standard, their implementation can differ from one hospital to another. For instance, some steps can be performed outside the hospital, in particular blood tests. The next section describes these options, the decisions involved, and the Key Performance Indicators (KPIs) associated to the process.

4. Management of Chemotherapy Production and Administration

Concerning the organization of outpatient chemotherapy, three different aspects need to be investigated. The first is the organizational variants, i.e. the main options that can be taken in such systems. The second important notion is the decisions that managers have to make to plan outpatient chemotherapy at the strategic, tactical and operational levels. The last aspect deals with the choice of the KPIs to measure the system's performance.

4.1. Organizational Variants

Although the clinical aspects of chemotherapy are universal, the practical organization of outpatient chemotherapy delivery varies from one hospital to another. These variants do not change the process as described in Section 3.2, but they modify its chronology (some steps can be performed days before treatment) and its operational management (e.g. with additional constraints on resource management). The various options as well as their corresponding risks and advantages are summarized in Table 3.

Table 3 - Options for outpatient chemotherapy delivery

Step	Options	Advantages	Risks
Blood test	**Chemo day in-house**	**Streamlined process Patients come only once**	**Patients wait Sensitivity to equipment failures**
	In-house on previous day	**Reduced waiting time on chemo day**	**Patients must come two days in a row**
	In external lab on previous day	**Reduced waiting time on chemo day Freed hospital lab capacity for other (more urgent) analysis**	**Poor hospital-lab coordination leads to a lost advantage and is time consuming**
Drug preparation	**Chemo day**	**Certainty on patient status: no wasted drugs**	**Patients wait Sensitivity to equipment failures**
	Previous day	**Drugs ready on patients' arrival if consultation is still on chemo day**	**Wasted drugs**
	Mixt	**Reduced waiting times Less wasted drugs than 100% on previous day**	**Patients with expensive drugs wait Still some wasted drugs**
Oncologist consultation	**Chemo day**	**Patients come only once**	**No early confirmation on patient status: patients wait drug preparation**
	Previous day	**Less waiting time because drugs can be prepared in advance Possibility to start chemo earlier**	**Patients have to come two days in a row**
Nurse-patient allocation	**Functional**	**Pooled resources: optimized utilization**	**Less possibility for patient-nurse connections**
	Primary	**Better patient-nurse connection**	**Lost productivity if the nurse's schedule cannot be filled**

The first difference is that in some hospitals, blood tests are done on the day before treatment (Dobish, 2003), either in the hospital or in town-based facilities, outside the hospital or treatment center (Sadki et al., 2013). Therefore, the blood test capacity can be assumed to be infinite for the hospital. It is however uncertain that test results will be transmitted on time prior to the patient's appointment at the treatment center. Similarly, oncologist appointments can take place one day before chemotherapy (Dobish, 2003). The reason is that the preparation time for some drugs is too long such that the patient's appointment needs to be scheduled on another day (Masselink et al., 2012). Finally, there are various ways for the assignment of nurse activities. A patient can be allocated to a nurse for her whole treatment, or she can be allocated to an available nurse each time she attends the treatment center. These two options are called "primary care delivery model" and "functional delivery model" (Liang and Turkcan, 2015). Some authors don't assign patients to nurses but rather match patient activities to available nurses, e.g. for the same patient the transfusion is set up by nurse A, but follow up during the infusion is performed by nurse B because nurse A is busy with other tasks (Hahn-Goldberg et al., 2014).

4.2. Decisions for Outpatient Chemotherapy Planning

Planning decisions in healthcare can be classified into strategic, tactical and operational decisions (Hulshof et al., 2012). For outpatient chemotherapy, all three levels have been tackled in the literature. A summary of all decisions tackled in the literature and the related references is given in Table 5.

Strategic Planning

Capacity dimensioning issues and facility layout are the only aspects of strategic planning addressed specifically for outpatient chemotherapy. This may be because strategic aspects such as geographic coverage and access are treated as part of wider cancer policies in public health and health policy journals rather than OM/OR research journals. Nurse staffing, chair/beds dimensioning, and doctor staffing are the three main issues considered (Liang et al., 2015; Liang and Turkcan, 2015; Matta and Patterson, 2007; Woodall et al., 2013; Yokouchi et al., 2012). In addition, one study analyzes lab capacity and pharmacy capacity (Baesler and Sepulveda, 2001) and another evaluates new investment in a pharmacy chemotherapy hood and resource allocation for drug delivery (Lu et al., 2012). Only one article tackles facility layout (Sepúlveda et al., 1999). Finally, one article considers the opportunity to open a focused outpatient clinic for breast cancer patients alongside a general chemotherapy clinic for other patients (Vanberkel et al., 2010).

Tactical Planning

The first decision concerning resource planning is medical planning, where the weekly consulting periods of oncologists are defined for a year (Sadki et al., 2013). The other decision addressed in the literature is appointment scheduling, where the rules for scheduling patients are defined (rather than the mechanisms for allocating a specific patient to a specific timeslot, which is an operational decision) (Baril, Gascon, Miller and Cote, 2016; Huggins and Pérez, 2014; Sepúlveda et al., 1999; Yokouchi et al., 2012). Finally, one article addresses process reengineering (Baril, Gascon, Miller and Cote, 2016). In the pharmacy, tactical decisions address the issue of advanced preparation. A policy must be defined to state which drugs can be prepared in advance, and which drugs can only be prepared once the administration to the patient is confirmed (Masselink et al., 2012; Merode et al., 2002; Vidal et al., 2010). Advanced preparation of labels in the pharmacy (without preparing the actual drugs in advance) is also addressed (Lu et al., 2012).

Operational Planning

The main operational decision, patient-to-appointment assignment, can be divided in two stages: planning and scheduling, where planning is the selection of the day of treatment (Condotta and Shakhlevich, 2014; Gocgun and Puterman, 2014; Sevinc et al., 2013; Turkcan et al., 2012) and scheduling is the choice of the time of the day at which the treatment should start (Condotta and Shakhlevich, 2014; Hahn-Goldberg et al., 2014; Liang et al., 2015; Liang and Turkcan, 2015; Santibáñez et al., 2012; Sevinc et al., 2013; Turkcan et al., 2012). Nurse-patient assignment is another operational planning decision. It consists of the allocation of a group of patients to a nurse for a specific day - *functional care model* - or the assignment of patients to a nurse for the duration of their whole treatment - *primary care model* (Condotta and Shakhlevich, 2014; Hahn-Goldberg et al., 2014; Liang and Turkcan, 2015). Staff-shift assignment is also studied for nurse scheduling operations, i.e. defining when each nurse will work for a defined horizon (Woodall et al., 2013). In the pharmacy, the issue of scheduling drug preparation is the only operational planning aspect addressed (Mazier et al., 2010).

Table 4 - Outpatient chemotherapy planning decisions

Decision/Issue	Definition	References
Patient planning	**Select the date of the appointment**	**(Condotta and Shakhlevich, 2014; Gocgun and Puterman, 2014; Sadki et al., 2013; Sevinc et al., 2013; Turkcan et al., 2012)**
Patient scheduling	**Select the start time of the appointment**	**(Condotta and Shakhlevich, 2014; Hahn-Goldberg et al., 2014; Huggins and Pérez, 2014; Liang et al., 2015; Liang and Turkcan, 2015; Santibáñez et al., 2012; Sepúlveda et al., 1999; Sevinc et al., 2013; Turkcan et al., 2012; Yokouchi et al., 2012)**
Nurse scheduling	**Define the working hours of nurses**	**(Baril, Gascon, Miller and Cote, 2016; Woodall et al., 2013)**
Medical planning	**Define the weekly consulting periods of oncologists for the next few months**	**(Sadki et al., 2013)**
Resource allocation	**Decide where to invest resources (nurses, chairs/beds, phlebotomists…)**	**(Baesler and Sepulveda, 2001; Lu et al., 2012; Matta and Patterson, 2007; Vanberkel et al., 2010)**
Drug preparation scheduling	**Define the pharmacy daily production schedule**	**(Masselink et al., 2012; Mazier et al., 2010; Merode et al., 2002)**
Drug preparation policy	**Define which drugs can be prepared in advance**	**(Masselink et al., 2012; Mazier et al., 2010; Vidal et al., 2010)**
Nurse-patient assignment	**Define the group of patients allotted to a nurse**	**(Condotta and Shakhlevich, 2014; Liang and Turkcan, 2015; Santibáñez et al., 2012; Turkcan et al., 2012)**
Doctor-patient assignment	**Define the group of patients allotted to a doctor**	**(Sadki et al., 2013)**

4.3. KPIs for Outpatient Chemotherapy

The decisions as described in the previous section have an effect on the system performance measures. These are defined through different types of KPIs. The first category is resource-focused and is strongly related to costs. The second category consists of patient-centered metrics, i.e. KPIs that measure the patient path in the system. The third category deals with qualitative indicators, mainly satisfaction metrics. The fourth and last category focuses on the performance of drug preparation in the pharmacy.

Cost and Resource-Focused Metrics

A part of the KPIs in outpatient chemotherapy are similar to outpatient appointment scheduling (AS) performance measures. Cayirli and Veral (2003) define AS performance as a linear combination of the mean waiting time of patients, the mean idle time of doctors, the mean overtime of doctors and the associated cost parameters. These three aspects are also important for outpatient chemotherapy, where doctor overtime is used as a performance measure (Sadki et al., 2013). In the case of outpatient chemotherapy, nurses are also a crucial resource whilst they don't intervene in outpatient consultation services. Therefore, authors studying outpatient chemotherapy planning account for nurses' idle time (Turkcan et al., 2012) and overtime (Liang and Turkcan, 2015; Turkcan et al., 2012; van Lent et al., 2009) in addition to that of doctors. Further metrics related to nurse scheduling and management are used. Existing studies employ indicators for nursing workload (Santibáñez et al., 2012) and workload excess measured in various ways (excess in patients over ideal practice (Santibáñez et al., 2012), sometimes analyzed as nurse overload (Liang and Turkcan, 2015), nurse shortage (Woodall et al., 2013) or daily workload excess (Condotta and Shakhlevich, 2014)). Some nurse planning studies use the number of clashes between nurses activities as an indicator to represent the number of occurrences when one nurse is planned for more than one activity at a given time (Condotta and Shakhlevich, 2014) (e.g. nurse A should at the same time be setting up the drips of patients X and Y).

Some metrics mix staff categories, such as the number of patients per total staff or specific staff category (e.g. nurse) per unit of time (van Lent et al., 2009), or average staff occupancy (Baesler and Sepulveda, 2001; Condotta and Shakhlevich, 2014). Closing time, similarly to clinic overtime, is a common indicator (Baesler and Sepulveda, 2001; Hahn-Goldberg et al., 2014; Liang et al., 2015; Sepúlveda et al., 1999; Turkcan et al., 2012), more rarely measured as the frequency of overtime (Matta and Patterson, 2007) or the average number of chairs busy at the expected end of service (Sepúlveda et al., 1999).

In addition to staff, another important resource in outpatient chemotherapy clinics is chairs or beds. Indicators are thus used to measure the utilization of beds: number of patients per bed per unit of time (van Lent et al., 2009; Vanberkel et al., 2010), or the rate of bed occupancy (Liang et al., 2015; Sevinc et al., 2013; Vanberkel et al., 2010; Yokouchi et al., 2012), or the variation of the number of beds needed along the year (Sadki et al., 2013).

Finally, global measures assess the available capacity (Huggins and Pérez, 2014; Santibáñez et al., 2012) and the number of patients per unit of time, also called throughput (Matta and Patterson, 2007; van Lent et al., 2009). In the current patient-centered paradigm, KPIs are also defined to follow patient trajectories.

Patient-Centered Metrics

The first patient-centered metric is the patient waiting time, which can refer to two different delays. First, the time between the patient's call and her appointment (Santibáñez et al., 2012; Turkcan et al., 2012), sometimes referred to as the *appointment lead time* (Nguyen et al., 2015). When working on the appointment lead time, some authors use indicators of fairness for planning across different categories of patients (Condotta and Shakhlevich, 2014), while others analyze the appointment notification lead time (Santibáñez et al., 2012). The waitlist size is also an indicator to evaluate the management of the appointment-making process (Santibáñez et al., 2012). The second type of patient waiting time is the delay on treatment day between the scheduled appointment and the actual beginning of the consultation or treatment (Baesler and Sepulveda, 2001; Baril, Gascon, Miller and Cote, 2016; Condotta and Shakhlevich, 2014; Liang et al., 2015; Liang and Turkcan, 2015; Masselink et al., 2012; Santibáñez et al., 2012; Sepúlveda et al., 1999; Woodall et al., 2013; Yokouchi et al., 2012), referred to as *waiting time* (Nguyen et al., 2015). Waiting time is sometimes further divided between waiting time before consultation and waiting time before treatment (Liang et al., 2015). At the daily level, system time is a common measure of the time between arrival and departure of patients (Huggins and Pérez, 2014; Matta and Patterson, 2007; Sepúlveda et al., 1999; Yokouchi et al., 2012). The ratio of waiting time on system time is analyzed by Yokouchi et al. (2012). Matta and Patterson (2007) insist on differentiating temporal indicators between days of the week, patient classes and process steps.

In addition to these KPIs, outpatient chemotherapy management requires some specific indicators linked to its clinical specificity and recurring aspect. This is why Gocgun and Puterman (2014) measure the number of patients for which the strict treatment plan could not be followed. An example of this would be if a patient has a protocol with an injection on day 1 and another injection on day 8, but for some reason it is not possible to see her on day 8 and the injection happens on day 9. This impacts the dose intensity and can reduce treatment efficiency (Lyman, 2009). In a similar way, Vanberkel et al. (2010) compute the number of patients that cannot be seen and must be rescheduled on the next day due to resource shortage.

Qualitative Indicators

Some qualitative indicators are also used. Patient satisfaction is not a typical indicator in OM/OR but it can be related to previously identified items, in particular waiting times. It is measured in some studies (Santibáñez et al., 2012; van Lent et al., 2009), sometimes as "number of complaints" (Baril, Gascon, Miller and Cote, 2016). Staff satisfaction is also analyzed (Santibáñez et al., 2012), as nurse turnover is an important concern in hospital management (Hayes et al., 2012; O'Brien-Pallas et al., 2006).

Pharmacy Indicators

The activity of drug preparation is fundamental for outpatient chemotherapy. It is measured through the workload (Santibáñez et al., 2012) or the number of preparations (Kergosien et al., 2011), and the productivity as the number of preparations per operator (Kergosien et al., 2011), and the staff utilization (Lu et al., 2012). Existing studies consider also temporal aspects, namely the pharmacy's delay to delivery (Kergosien et al., 2011; Lu et al., 2012), the rates of on-time and tardy jobs (Kergosien et al., 2011; Mazier et al., 2010), and the expected tardiness (Kergosien et al., 2011). Finally, drugs can be prepared in advance to avoid waiting times on the day of chemotherapy. If drugs are produced in advance (i.e. before the doctor has examined the patient and decided that she is in sufficiently good physical condition for treatment), there is a risk that the drug will be prepared but the patient will not be able to receive it. In such cases, the policy for advanced drug preparation is evaluated through the quantity and the cost of wasted drugs (Masselink et al., 2012; Merode et al., 2002; Vidal et al., 2010). Merode et al. (2002) propose also to evaluate the economic value of the drug inventory that is constituted by advanced preparation.

Now that outpatient chemotherapy has been presented from an organizational perspective, specificities on its modelling and analysis are next described.

5. Specific Complexities when Modelling Outpatient Chemotherapy Planning

Although outpatient chemotherapy planning shares some characteristics with other outpatient clinic planning issues, it has specificities which make it quite different to analyze and model. Three characteristics make it an original problem to study: coupled-operations issues, tolerances in planning and uncertainties on patient status. These three aspects have managerial and analytic implications that will now be detailed.

5.1. Coupled Operations Issues

Condotta and Shakhlevich (2014) show that the problem of outpatient chemotherapy planning lies in the category of scheduling coupled-operations jobs with exact time-lags. Coupled operations scheduling was first introduced for radar operations by Shapiro (1980). It is applied to cases when an operator or a machine has multiple tasks to perform on a product and these tasks need to be separated by a fixed time interval. When the resource is not working on one product because this job is in-between two tasks, it can work on another unit. This is typically the case for radars when they emit a signal, which then flows until it is reflected by a target, and comes back to the radar for reception. The radar is busy with this job during emission and reception but is available between these two tasks. From an algorithmic point-of-view, coupled operations scheduling on a single machine is NP-hard (Potts and Whitehead, 2007).

In our case, coupled operations can be identified at two levels: for patient planning and for patient scheduling. For patient planning, i.e. determining the days of the appointments, multiple appointments are made for a patient with a specified delay between them. This is because chemotherapy works in cycles. Patient scheduling, i.e. determining appointment time once the date has been chosen, is another coupled-operation problem. On a treatment day, patients undergo multiple operations separated by a predefined duration. The nurse needs to be present to set up the infusion. She does not need to stay with the patient during the infusion, but she needs to come back at the end of the infusion. Patient scheduling is therefore a coupled operations problem.

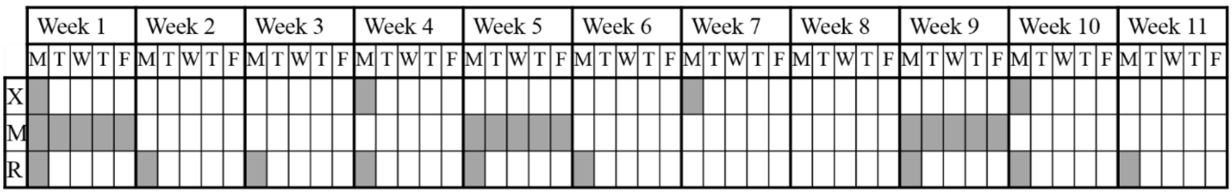


Figure 10 - 11-week schedule for the Xelox (X), Mayo Clinic (M) and Roswell Park (R) regimens (only working days are indicated)

To clarify the chemotherapy specificity, an illustration is given next using the examples of the regimens presented in Section 3.1. In Figure 10, the three different regimens for colon cancer are shown as well as the appointments needed in these regimens over an 11-week horizon. For the Xelox regimen, the patient comes every 3 weeks for an injection and takes oral capacitabine for the first 14 days of the cycle. Therefore, the patient comes on day 1 of week 1, then on day 1 of week 4, day 1 of week 7, etc. The gray cases represent the days when the patient has to come to the hospital. Figure 11 shows what happens during the day for six patients followed by the same nurse. For the Xelox regimen, the patient comes for a 2-hour injection. It is assumed that the nurse needs 15 minutes to set the drip and 15 minutes to take it off. Between these two periods, the nurse is monitoring the drip but not actively involved in patient care. For the Mayo Clinic regimen, patients get a rapid infusion followed by a bolus (a quick subcutaneous injection). These patients only require two consecutive injections so they have a very short sojourn time at the clinic (15 minutes in Figure 11).

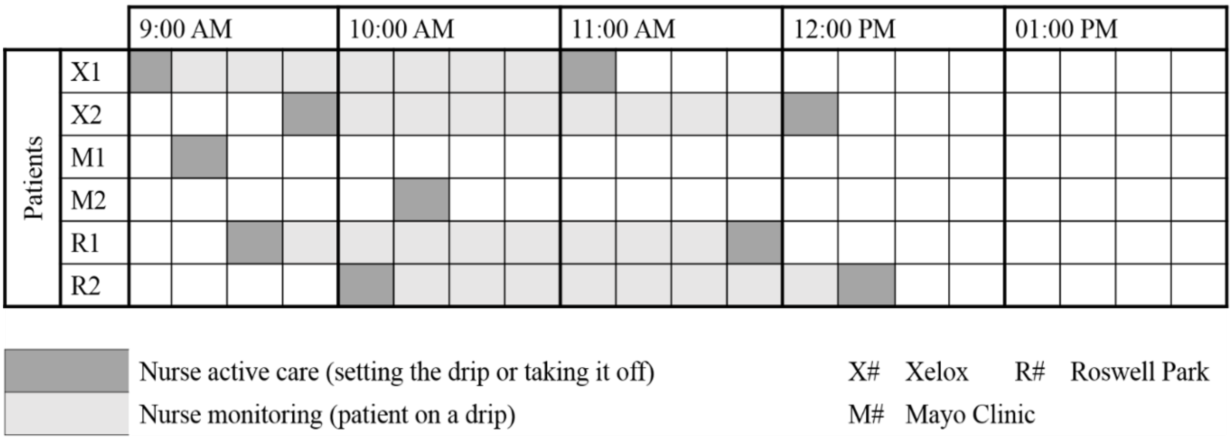


Figure 11 - Intra-day planning for six patients followed by the same nurse, with Xelox (X), Mayo Clinic (M) and Roswell Park (R) regimens (each hour is divided in 15-minutes period)

A nurse can manage a set of patients, depending on how much attention the patients do need, i.e. their “acuity levels” (Liang and Turkcan, 2015). She can only “actively care” for one patient at a time. Thus there cannot be two cases with “nurse active care” in the same column in Figure 11. Higher acuity levels are required for example for a patient with respiratory assistance. Figure 11 shows only simple cases. It may be the case that a patient has to get a first infusion, then the drugs are changed for a second infusion, and only thereafter the patient is released. In such cases, the nurse is required to set up the infusion, then to change the infusion for the second drug mix, then to release the patient. This example illustrates that nurses can have more than two “active care” timeslots per patient.

Planning coupled events is different from planning single operations. To do so, various methods have been proposed. At the tactical level, medical planning (defining weekly consultation periods of oncologists for the next months) has been addressed by Sadki et al. (2013) using Mixed Integer Programming. The method consists of a three-stage approach to plan morning sessions first, then afternoon sessions, and finally improve solutions locally. At the operational level, patient planning has been modeled as a Multiple Knapsack problem (Sevinc et al., 2013). For patient scheduling, multiobjective optimization can be used to identify tradeoffs between patient waiting-time, nurse overtime and nurse excess workload (Liang and Turkcan, 2015). Constraint programming has also been used for dynamic patient scheduling, in an approach called dynamic template scheduling (Hahn-Goldberg et al., 2014). This approach can be extended to cover both patient planning and scheduling and is then called multilevel template scheduling (Condotta and Shakhlevich, 2014).

Finally, both planning and scheduling have been tackled with Mixed Integer Programming using heuristics for the numerical resolution (Turkcan et al., 2012).

5.2. Tolerances on Treatment Dates

Another distinctive characteristic of chemotherapy planning compared to other outpatient planning activities is the presence of due dates for appointments, and tolerances on the dates of appointments, which creates a time window for planning (Gocgun and Puterman, 2014). Regimens must be followed strictly, e.g. when the second session must be planned 14 days after the first session, but they often include a tolerance margin of one or two days before or after the target date (Santibáñez et al., 2012). Tolerance values are set by oncologists when the regimen is created. It is acceptable to plan appointments in this tolerance zone as it is assumed that the dose intensity won't vary enough to decrease treatment efficiency. In practice, protocols with tolerances are common: in a study of a large cancer treatment center in Canada, more than 82% of the patients were following a protocol with a tolerance margin of plus-one or minus-one day (Santibáñez et al., 2012). Since they give more flexibility to planners, tolerances can be used to optimize scheduling and improve the efficiency of the clinic without compromising the efficacy of the treatments.

To take into account tolerances, Gocgun and Puterman (2014) develop a two-part cost function. The first part defines costs for scheduling outside the tolerance zone. The cost is zero when the appointment date is inside the tolerance zone. Outside the tolerance zone, the cost is proportional to the delay between the target date and the actual appointment. A first cost coefficient α is associated for planning too early and a second cost coefficient β for planning too late. Another part of the cost function is the cost of serving a patient through overtime inside his tolerance zone. If α and β have high values, planning outside tolerance zones has a higher cost and overtime will be preferred. In the reverse situation, the system will bend towards scheduling outside tolerances.

5.3. Uncertainty on Patient Status and Its Effect on Drug Preparation

No-shows are a typical issue in outpatient clinics (Muthuraman and Lawley, 2008). A no-show is defined as a patient who does not show up at the time of her appointment. One of the main distinctive features of outpatient chemotherapy planning is that no-shows are quite rare. Instead, a patient who shows up can be actually not suitable for treatment. Based on the blood test or during the consultation, a patient can indeed be declared too weak for chemotherapy. At the Netherlands Cancer Institute, 10% of the patients whose blood is tested and 5% of the patients without blood tests are found to be unfit for treatment (Masselink et al., 2012). This is due to the disease itself, and to the side-effects of chemotherapy.

This feature has one important immediate consequence. With such rates of unfit patients, if all chemotherapies were prepared in advance the quantity of spoiled drugs would be huge. As some drugs cost up to thousands of dollars, this would be impossible. Therefore, pharmacies will be reluctant to prepare in advance without a guarantee that the patient will receive her treatment. A trade-off must be found between the risk of spoiling drugs and patient waiting time. In the literature, the Analytic Hierarchy Process has been used for this purpose (Vidal et al., 2010), as well as queueing theory (Masselink et al., 2012). Simulation can be employed to identify the effect of different policies (Merode et al., 2002).

To enable advanced preparation with a high level of certainty on the patient's status, some hospitals plan consultations on the day before chemotherapy (Dobish, 2003). However, this solution drives patient transportation costs up and is not popular among patients (Lau et al., 2014). Other hospitals call patients one or two days before treatment to better anticipate their status (Coriat et al., 2012; Scotté et al., 2013). Patients often agree with such a procedure (McCann et al., 2009). A study by Scotté et al. (2013) reports that the percentage of drugs which were produced but could not be administered dropped from 6% to 2% of the total production due to a more reliable information on patients' physical status, and the patient waiting time was reduced by 66 minutes thanks to more preparations in advance. Another benefit in terms of the reduction of the number of unplanned hospitalization has been also underlined (Coriat et al., 2012).

6. The View from Practice: Outpatient Chemotherapy in a French Public General Hospital

Both managerial and analytical specificities of outpatient chemotherapy have now been presented. It is now interesting to understand and assess how well the existing literature addresses the important managerial challenges. In this section, we conduct a case study to investigate the theory-to-practice gap. The objective is to evidence, from practice, new opportunities for future research. The case study is conducted at Henri Mondor hospital, a French public university hospital near Paris. As a reminder, Henri Mondor hospital is a large general hospital (1,000+ beds, 80,000+ inpatient admissions/year, and 300,000+ outpatient visits/year), and the oncology department performs around 4,000 outpatient chemotherapy sessions per year. Around 20,000 chemotherapy doses are prepared in the pharmacy each year.

In the literature, most studies focus on cancer treatment centers or integrated cancer treatment clinics inside bigger hospitals (Baesler and Sepulveda, 2001; Gocgun and Puterman, 2014; Hahn-Goldberg et al., 2014; Huggins and Pérez, 2014; Masselink et al., 2012; Matta and Patterson, 2007; Sepúlveda et al., 1999; Woodall et al., 2013). Few papers study outpatient chemotherapy planning in general hospitals (Lu et al., 2012; Merode et al., 2002; Vidal et al., 2010; Yokouchi et al., 2012). Our analysis shows that outpatient chemotherapy planning for oncology departments in general hospitals differs on several points from what has been studied in the literature. The case study allows us to identify the related gaps between theory and practice.

6.1. Coordination with Actors outside the Hospital

In most articles on outpatient chemotherapy planning, blood tests are performed in the hospital, on the day of chemotherapy administration (Liang et al., 2015; Merode et al., 2002; Turkcan et al., 2012; Woodall et al., 2013; Yokouchi et al., 2012). In the studied hospital, blood tests are performed two days before chemotherapy delivery, in an external medical lab. This policy reduces waiting times and allows advanced drug preparation based on blood test results. It also saves capacity at the hospital's lab for inpatients and urgent cases. However, the hospital has no control over external labs. Therefore, coordination needs to be achieved between the oncology department and the external labs so that blood test results are transmitted on time. If the results are not transmitted on time, drug preparation cannot be started in advance. This is an additional source of uncertainty: the hospital depends on external actors. The situation is similar with respect to patient transportation. Patients handle on their own the transportation when they come to the hospital. However, for the return trip, it is often the nurse who calls the ambulance or the taxi. Patients regularly wait long times for their ambulance or taxi. This can be due to the transport supplier, or to nurses not calling soon enough.

6.2. Coordination between Hospital Departments

In the existing models centered on the pharmacy, it seems to be generally assumed that the pharmacy has only one client department requiring chemotherapy drugs (Masselink et al., 2012; Mazier et al., 2010). In our case, as shown in Figure 12, chemotherapy drugs are administered in different units: the oncology department, but also the hematology department, dermatology, etc. Outpatient oncology represents 37% of chemotherapy administrations, 26% for outpatient lymphoid hemopathies, and 11% for inpatient lymphoid hemopathies, followed by 10 % for inpatient clinical hematology. Overall, over 40 different units have ordered at least one chemotherapy preparation over an 18-month period. Even though the eight biggest client departments account for 90.6% of preparations, which makes the 30-odd others small variables, all these client departments are separate organizations with their own proper objectives, practices and clinical specificities. Scheduling in the pharmacy is complex: the pharmacy does not only need to satisfy the priorities of one department (the outpatient oncology department), it needs to juggle with different queues of orders. Fairness between departments is an additional constraint for the pharmacy. Moreover, actions taken to improve the situation locally, such as new patient planning rules in the oncology department for instance, will impact the workload of the pharmacy and may make the situation worse. The system is not only one where flows of drugs and patients have to be synchronized, it is also one where a single capacity must accommodate multiple heterogeneous clients.

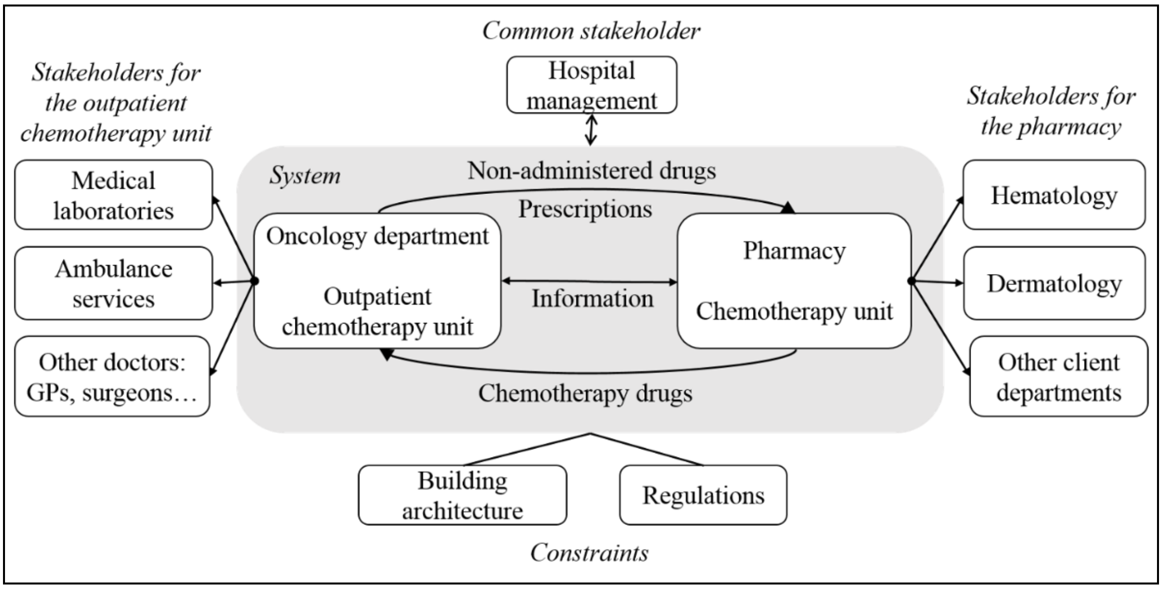


Figure 12 - Stakeholders for outpatient chemotherapy in the studied hospital

6.3. Drug Preparation Policy

Most papers assume that drugs are prepared on the day of chemotherapy delivery (Huggins and Pérez, 2014; Liang et al., 2015; Masselink et al., 2012; Merode et al., 2002; Turkcan et al., 2012; Woodall et al., 2013; Yokouchi et al., 2012). One paper describes a case where part of the preparation (the administrative, office part) is done in advance (Lu et al., 2012). Only two papers (Masselink et al., 2012; Vidal et al., 2010) explicitly describe a mixed policy where part of the drugs are prepared before the patients see the oncologist and the rest is prepared after the medical examination. This is also the case in the studied hospital. Only for 16% of the preparations does the pharmacy wait for confirmation from the doctor (but these preparations account for 40% of the total value of preparations). For all other preparations, blood test results are transmitted before the patient's arrival to the hospital, and if they are positive, the preparation can start in advance. However, if the patient is ultimately not in shape for receiving chemotherapy, the drugs are then returned to the pharmacy. Returned drugs can be re-allocated during their stability period, but after that they must be destroyed, which is a net loss for the pharmacy. The value of all chemotherapy preparations is over 5 million euros per year: the trade-off in the drug preparation policy is crucial.

7. Discussion: Opportunities for Future Research

We have presented the organizational aspects of outpatient chemotherapy and the related challenges in terms of modelling and analysis. Based on the case study we carried in a French hospital, we discuss in this section the opportunities to reduce the theory-to-practice gap.

Most of the work published in the literature has focused on hospitals working as integrated care centers, rather than on "general hospitals". In general hospitals, coordination issues are more challenging. One conclusion could be that all hospitals ought to change towards the integrated cancer center model. However, this is difficult, especially in less densely populated areas where hospitals face a lower number of patients with a wide range of pathologies. Therefore, in many hospitals, multiple departments will still have to collaborate to ensure good quality of care at high levels of efficiency. An efficient chemotherapy planning requires then an appropriate coordination between the involved subsystems: the lab for blood tests, the pharmacy for drug preparation and the outpatient clinics for drug administration. Different resources, with different skills, responsibilities, objectives and views on the performance of the system, need also to collaborate. This is a typical case where a focus on a subsystem's performance can deteriorate the global system's performance (Matta and Patterson, 2007). New methods are thus required to tackle such challenging issues. In what follows, we distinguish the methods that could be used and we highlight that the link between patient waiting time, a common indicator and objective in the reviewed studies, and patient satisfaction needs to be studied further for outpatient chemotherapy.

7.1. Multiple Departments: the Challenge of Coordination

Although models of single departments "ignore the inherent complex interactions between decisions for different services in different organizations and departments" (Hulshof et al., 2012: 158), models with multiple departments are rare in healthcare (Vanberkel et al., 2009). Our case study shows that, in similar cases at least, the pharmacy, the outpatient clinic and the interaction between them should be modeled. In our review, except in two papers (Matta and Patterson, 2007; Merode et al., 2002), the pharmacy is either the sole concern of the study (for studies of drug preparation scheduling) or considered as a simple step in chemotherapy administration. The reason could be that, in the integrated cancer centers studied in the literature, the pharmacy is a subunit of the outpatient department, or because drugs are prepared directly by nurses in the clinical department. In French hospitals, most pharmacies have been centralized to increase pharmaceutical control and traceability (Cazin and Gosselin, 1999; Favier et al., 1996; Larrouturou et al., 1992; Martin et al., 2004). Similar recommendations have been issued in the United Kingdom (Turner et al., 2011) and Germany (Deutsche Gesellschaft für Onkologische Pharmazie, 2009). The 2008 Quality Standard for the Oncology Pharmacy Service issued by the European Society of Oncology Pharmacy states that "the centralized preparation of CMR (carcinogenic, mutagenic and reprotoxic) drugs must take priority over distributed preparation" (German Society of Oncology Pharmacy, 2008: 49). Therefore, our case study can be considered as representative of many European hospitals.

In France, the centralization of cytotoxic drug preparation allowed to buy appropriate equipment: isolators instead of vertical laminar air-flow hoods (Cazin and Gosselin, 1999; Larrouturou et al., 1992). Isolators induce less risks of contamination and the centralized production allows cost savings (Favier et al., 1996). However, from a production angle, they are less flexible than a decentralized production with vertical laminar air-flow hoods: for instance, in the studied hospital, the machines have a 15 minutes sterilization phase before preparation and a 5 minutes sterilization phase after preparation, and they work in batches of four preparations. Single-piece flows are almost impossible. As a consequence of this centralization and operational structure, the pharmacy in the studied hospital is a separate department, with different objectives, which serves multiple departments. Reducing its complexity to a single stochastic variable, as is often the case in the literature, would be a risky simplification.

Various modelling techniques could be applied to multi-department issues. Mathematical programming and simulation, very popular in healthcare management science, can be developed in this direction. Moreover, to take into account the interests of multiple departments (pharmacy and outpatient departments), “softer” approaches including the interests of all stakeholders should also be investigated. In the papers reviewed here, only van Merode et al. (2002) mention the “political” dimension of re-organizations in multi-department systems. If these dimensions are not taken into account, “actors will try to fulfill their own particular interests” (Merode et al., 2002). Implementation of recommendations could then be jeopardized, which is a common issue in healthcare (Brailsford, Harper, et al., 2009; Brailsford and Vissers, 2011; Fone et al., 2003; Proudlove et al., 2007). In the case of simulation, projects using simulation “with a high level of implementation and user engagement in the simulation part” are very rare in healthcare compared to other sectors (Jahangirian et al., 2012). In the papers reviewed here, many use real data but only a limited number provide elements of implementation into regular practice – nine out of twenty-five (Baril, Gascon, Miller and Cote, 2016; Liang et al., 2015; Lu et al., 2012; Masselink et al., 2012; Mazier et al., 2010; Santibáñez et al., 2012; Sevinc et al., 2013; Vidal et al., 2010; Woodall et al., 2013) (the implementation of the results of Mazier et al. (2010) is presented in another paper by Kergosien et al. (2011)). This is still limited with regards to implementation. Soft OR methods could help here, as they have been developed to tackle human and political issues in order to overcome "the abstraction and impracticability of much OR/MS research" noticed in the late 1970’s (Mingers, 2000). A way forward could be to combine Soft OR methods with traditional modelling and simulation techniques. This type of multimethodology has already been successfully applied in healthcare (Holm et al., 2013; Kotiadis, 2007; Lehaney and Paul, 1996). In the reviewed papers, Santibañez et al. (2012) have combined process observation and mapping with simulation. Another project in the Netherlands has combined qualitative (van Lent et al., 2009) and quantitative (Masselink et al., 2012) approaches. A third paper in Canada combines simulation with Lean management and a business game (Baril, Gascon, Miller and Cote, 2016).

7.2. Patient Satisfaction and Waiting Times

Besides multi-department coordination, additional research should be undertaken on patient satisfaction predictors in outpatient chemotherapy. It is usually implicitly assumed that reducing patient waiting time is a priority, but evidence to back this objective is limited. Outpatient chemotherapy is different from emergency departments, where waiting time is a clinical variable. In outpatient chemotherapy, if decreasing waiting times has a limited impact on patient satisfaction, then actions should be undertaken to reduce it mainly for operational reasons (throughput, resource utilization) and the cost of actions to reduce waiting times should be evaluated precisely. The literature provides no definitive answer on the link between waiting times in chemotherapy and patient satisfaction. In the study of satisfaction factors in outpatient oncology care by Gesell and Gregory (2004), waiting time in the chemotherapy area is only the 10th item whereas waiting time in the registration area is ranked 6th. Actually waiting time is not a well-studied dimension of cancer patient satisfaction with the provided care (Sandoval et al., 2006). In a study by Sandoval et al. (2006), “Wait time from arrival to chemo treatment” and “Waited longer than expected for chemo treatment” are the areas with the highest problem frequency among the 1,044 Canadian chemotherapy patients who answered (66.7% and 70.4% respectively). However, they are not the best predictors for satisfaction and rank far behind management of confidential information and respect and communication aspects. In the literature review on the satisfaction determinants in cancer treatment by Lis et al. (2009), waiting times are regularly identified as dissatisfaction factors but only one study spots waiting time as a satisfaction predictor. In this study by Fossa et al. (1996), “Less than 1.5 hours at the out-patient department” is the highest predictor for patient satisfaction, so system time is important, but waiting time is not mentioned. System time depends on waiting time but also on treatment duration, which is a clinical variable, independent of the way operations are managed. More evidence needs to be gathered to understand the link between waiting time and patient satisfaction.

8. Conclusion

Although research on outpatient chemotherapy planning is rather young, it is quickly developing. Given the rising number of cancer cases, the ageing of the world population and the budget constraints, research on this topic should keep expanding. In this article, the literature is reviewed to identify the distinctive features of outpatient chemotherapy planning. Organizational aspects, with specific KPIs and inter-department structures, are evidenced. Modelling specificities are also underlined. By confronting the literature to the reality of a French public general hospital, some points are highlighted and should be kept in mind when tackling outpatient chemotherapy. One key point is to consider outpatient chemotherapy as a multiple department issue when drug preparation is centralized in the hospital. Future research should follow this systemic view rather than model the involved actors separately.

II. Multidepartment Integration: a Multimethodology to Initiate a Change Program in a Hospital's Cancer Division[5]

In this chapter, we present the results of an action-research project in a French university hospital. We combine the Viable System Model (VSM) and Kotter's 8 steps for leading change to initiate a change program aimed at integrating the processes needed for outpatient chemotherapy in this hospital. The VSM allows the diagnosis of the existing organization, and the elaboration of a working plan. The plan is concurrently implemented using Kotter's 8 steps. The analysis of this projects yields two contributions. The first one is methodological, on the problem-solving approach we used. The VSM is powerful when embedded in a change management process, and Kotter's 8 steps fit well to initiate change. The second contribution is on the factors promoting or impeding integration, and is based on experiential learning during this project. We contribute add to existing knowledge by identifying these factors and propose an update of existing models in the light of our case study.

[5] Submitted to the *European Journal of Operational Research.*

1. Introduction

To move forward in our understanding of hospital integration and the ways to achieve it, previous examples—e.g. Paltved et al. (2016) in a Danish surgery ward or Lehaney and Paul (1996) in a British outpatient service—have proved action research (AR) to be a valuable approach to learn about (i) the adaptation of methods to this new context and (ii) the dynamics of change in hospitals. In this article, we use action-research (Checkland and Holwell, 1998; Coghlan and Brannick, 2014; Coughlan and Coghlan, 2002; Eden and Huxham, 1996) as our overall approach to study multidepartment coordination in the cancer division of a French hospital. Our case study addresses the provision of outpatient chemotherapy, a service which is spread on different units in the hospital. The lack of coordination between these units generates long waiting times and efficiency losses. Starting from the problem posed by the head of the oncology department, we develop a method to diagnose the system and initiate a change program aimed at promoting inter-departmental integration.

To theoretically frame our intervention, we use Stafford Beer's Viable System Model (VSM). The VSM takes a holistic, systemic perspective on organizations and it emphasizes coordination aspects. Indeed, the VSM stems from cybernetics, the discipline that provided researchers with fundamental concepts in the analysis of information flows, such as *feedback* or *variety engineering*. Using the VSM, we describe an AR project in the cancer division of a French university hospital. In this context, the VSM needs to be integrated in a change process. To this end, we use a change management approach based on Kotter's 8-step model (Kotter, 1996). The VSM and the 8 steps go along well because they share the same functionalist perspective. They are also complementary: the VSM does not provide practitioners with a change process, only with an ideal organizational structure; at the opposite, the 8 steps are a change process which can be adapted to suit any type of change. The project proves that they work well together in the first stages of a change program. At the end of the project, two initiatives are launched that tackle specific issues of integration, diagnosed with the VSM. A shift in the way the system is considered and managed by department managers is noticed. First process changes are generated by dedicated working groups. The intervention is considered successful in its aim to shift perspectives and start a change dynamic, or "unfreeze" the situation in Kurt Lewin's terms (1947).

This study makes two contributions. They stem from the analysis of the problem-solving methodology we proposed, and from its application. First, we propose a method for structuring and initiating a change program in a hospital, when integration between departments is the objective. To do so, we show an example of the VSM encapsulated in a change process, informed by Kotter's change management theory. This is complementary to Keating's application of VSM in a hospital which focuses on the analytic power of the VSM (Keating, 2000). Second, through the reflections on this project we contribute to the literature on challenges to deeper integration between hospital services, and in particular we review Drupsteen et al.'s recent study (2016) in the light of our experience. The findings of Drupsteen et al. are validated, but some elements also appear in our case which we include in their framework.

The chapter is structured as follows. In Section 2 we review the literature on integrated care, on the VSM and on Kotter's 8 steps. In Section 3, we introduce our project, its context and the AR process we implemented. In Section 4 the results of the project are laid out. Section 5 discusses these results in relation to the literature and specifies what learnings we draw from this AR project. The chapter ends with some concluding remarks.

2. Literature Review

The literature related to this paper bears on three subjects. The first stream deals with integrated care. The second one is about Stafford Beer's VSM. The third one discusses John Kotter's 8 steps for leading change.

2.1. Integrated Care: Definitions

Integration is a familiar concept in OM. Lillrank provides a definition: "Integration is the combining of several specialized and differentiated resources and contributions to create an output that is a system consisting of several parts. Each part needs to contribute to the output, but also submit to the demands of the whole. Integration means giving up some of the benefits of specialization for the sake of the system." (Lillrank, 2012: 8). Van der Vaart and Van Donk (2004) identify three levels of integration in the context of supply chain integration:

- The *transparency stage* were information is shared between participants
- The *commitment and coordination stage* were participants share all relevant information and commit to certain mutual adjustments
- The *integrative planning stage* were major decisions for the supply chain are centralized

In healthcare, McDonald et al. (2007) define integration as "the deliberate organization of patient care activities between two or more participants (including the patient) involved in a patient's care to facilitate the appropriate delivery of healthcare services." Kodner and Spreeuwenberg (2002: 3) go further in their definition by qualifying integration as a process resulting in integrated organizations : "Integration is a coherent set of methods and models . . . designed to create connectivity, alignment and collaboration within and between the cure and care sectors. The goal of these methods and models is to enhance quality of care and quality of life, consumer satisfaction and system efficiency for patients ... cutting across multiple services, providers and settings".

Integration is much called for, but there is little study of multidepartment coordination in OR (Vanberkel et al., 2009) or OM (Drupsteen, 2013). Drupsteen et al. (2016) identify five antecedents for hospital integration:

- Two inhibiting antecedents, shared resources and uncertainty/variability;
- Two initiating antecedents, process visibility and performance management; and
- One facilitating antecedent, information technology.

They also consider facility layout in their original model but discard it because empirical material does not support it. More generally in OM, coordination, "the arrangement of roles and tasks into an organized whole" (Lillrank, 2012: 8), is the way to achieve integration (Glouberman and Mintzberg, 2001; Lillrank, 2012). The VSM addresses the challenge of coordination using cybernetic principles, with specific emphasis on the balance between autonomy/differentiation and cohesion/integration

(Pérez Ríos, 2012). It is therefore an appropriate tool for the study of coordination in hospitals. We now present the theory of the VSM and its applications.

2.2. The Viable System Model

Origins and Theory

The theory for the VSM was developed by Stafford Beer in two books in the 1970's, *Brain of the firm* (1972) and *The heart of enterprise* (1979). He later presented the model in a guidebook for practitioners, *Diagnosing the system for organizations* (1985). A short paper to introduce the model was also published in 1984 in the *Journal of the Operational Research Society* (Beer, 1984). Research on the subject was then pursued by Jackson (1988, 1990), Leonard (2009), Pérez Ríos (2012), Schwaninger (2006; Schwaninger and Scheef, 2016) and by Espejo with his colleagues Reyes (2011) and Harnden (1989).

The theoretical roots of the VSM are cybernetics, developed for managerial issues into *organizational cybernetics* (Jackson, 2003). *Organizational cybernetics* should not be confounded with *management cybernetics* (Jackson, 1991). The latter takes a mechanistic perspective on organizations, and does not consider the observer as part of the investigation. This is in contrast with Beer building his VSM from fundamental cybernetic principles, thus bypassing any metaphoric reasoning with machines or living organisms. Furthermore, Beer's approach encapsulates the observing system in the study and thus belongs to *second-order cybernetics* (Jackson, 1991: 104).

As shown in Figure 13, the VSM describes viable systems as made of five interconnected systems, numbered from 1 to 5:

- System 1 is made of the units that implement the function of the system, each with its own management and environment. System 1 is the *production function* of the system.
- System 2 is a *coordination function* between the units of System 1. It ensures that they work along in a coherent way, for instance for production planning between different units to avoid bullwhip effects and similar issues.
- System 3 is the *control function* of the system. It focuses on the inside-and-now of the system, monitoring the performance of System 1. It ensures resource allocation to System 1 based on the information from System 2 and from System 3*.
- System 3* performs *sporadic audit* of System 1 and reports to System 3.
- System 4 is the *development function* of the system. It is connected with the environment of the system (which does not coincide with the sum of all System 1 units' environments). It is in charge of analyzing the environment of the system and putting in perspective the information on the operations of the system transmitted by System 3.
- System 5 is the *policy function*. This is where strategic decisions are made. System 5 must also represent the system-in-focus to other systems.

All systems are richly connected by information channels, which must follow the laws of requisite variety ("only variety can destroy variety", i.e. the system's variety must match with the incoming variety from its environment). Figure 13 shows these channels between the different components. A final important concept is that the model is recursive: each System 1 unit can be analyzed with the VSM, and the system-in-focus is also embedded in a larger system which can be analyzed with the VSM. For further details on the VSM, the reader is referred to Beer's original writings (1972, 1979, 1984, 1985), Jackson's textbooks (1991, 2003) or the more recent books of Espejo and Reyes (2011) and Pérez Ríos (2012).

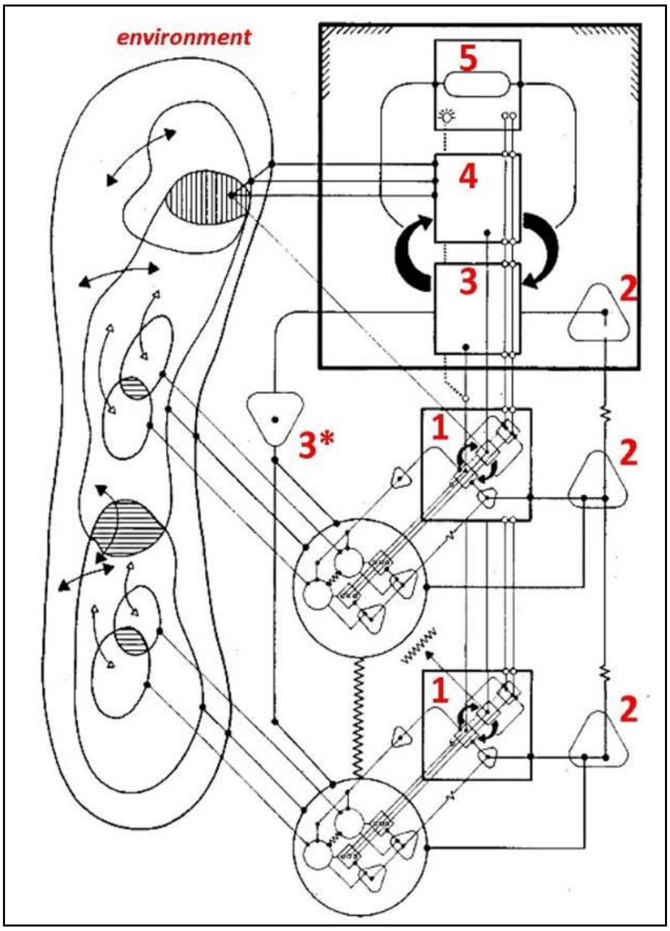


Figure 13 - The VSM with all constitutive systems numbered (adapted from Beer, 1985)

Applications and Validation

The empirical validation of the VSM is mainly based on numerous successful case-studies, e.g. (Leonard, 2009; Paradissopoulos, 1991; Schwaninger, 2006). Recently published applications of the VSM address a wide range of issues, such as disaster response management (Preece et al., 2013), environmental management (Espinosa and Walker, 2006), strategic management (Espinosa et al., 2015), eco-community organization (Espinosa and Walker, 2013) and electricity generation and distribution planning (Terra et al., 2016). To complement this approach, Schwaninger and Scheef carried quantitative research on the relationship between firms' compliance with the VSM's principles and their success. Their questionnaire study indicated a relation between VSM concepts and effective organizational performance and viability (Schwaninger and Scheef, 2016).

Concerning the field of healthcare, applications of the VSM are scarce. A quick search on the *Web of Science* (Thomson Reuters, 2016) on October 6th, 2016, with the following combination of keywords: [(("viable system model" OR "cybernetic*") OR "vsm") AND (("hospital*" OR "healthcare") OR "healthcare")], lists 46 journal articles, none of which is relevant to our study. Thanks to Mingers and White (2010), who review applications of systems thinking in management, including the VSM, we are aware of one study addressing hospital management with the VSM, by Keating (2000). In this study, Keating proposes a method based on the VSM for structural analysis of organizations and then applies it to an American 600-bed hospital. The focus is more on the proposed systems-based methodology than on the specific healthcare context. The methodology is judged to be satisfying because it allowed for the identification of multiple "structural pathologies". It is not mentioned whether this diagnosis was followed by action: the study stops after the diagnosis of the hospital's structure has been established by the author. We wish to go further and to study whether VSM diagnosis can lead to action being taken in a hospital. To achieve this, we need to include the VSM in a change process. We now present one such process, namely, Kotter's 8 steps for leading change.

2.3. Kotter's 8 Steps for Leading Change

In 1995, John Kotter described in a *Harvard Business Review* paper what he considered to be the 8 most important factors in the failure of change efforts after observing "more than 100 companies" (Kotter, 1995). He then proposed an 8-step normative model for change management, designed to avoid the traps previously identified. This was the argument of his 1996 book, *Leading change* (Kotter, 1996). The 8 steps are:

1) Establishing a Sense of Urgency
2) Creating the Guiding Coalition
3) Developing a Vision and Strategy
4) Communicating the Change Vision
5) Empowering Employees for Broad-Based Action
6) Generating Short-Term Wins
7) Consolidating Gains and Producing More Change
8) Anchoring New Approaches in the Culture

The model has been very influent since its first publication (Appelbaum et al., 2012). The 1995 *HBR* article and the 1996 book were in January 2014 the most cited publications on organizational change (Hughes, 2016a). This situation is paradoxical, as these publications are more of "professional literature" than academic, since they do not discuss previous research in the field or characterize precisely the contexts of the case studies (Appelbaum et al., 2012; Hughes, 2016a). In a recent polemic paper, Hughes argues that *Leading change* is a landmark book in change leadership studies, but that its neglect for the ethics of organizational change is problematic (Hughes, 2016a: 463–465).

However, from a pragmatic point-of-view, Pollack and Pollack (2015) identify action-research studies that successfully applied the model in real-life conditions and contribute themselves to this research effort. They conclude that Kotter's process is an "effective way of managing change" (2015: 63), although it requires some adaptations. They question the linearity of the process, and the unicity of the change process. In their case, multipole change projects, each with its own guiding coalition and its timeframe, concurred in the organization. In each of these concurrent projects, they experienced the 8 stages mixing rather than neatly succeeding each other. In another study, Ansari and Bell (2009) underline the fact that Kotter's process needs to be complemented with other frameworks to suit their needs, in particular the first step "establishing a sense of urgency" needed more work in their project than what's mentioned by Kotter. Some examples of applications of the 8-step model in the healthcare sector include the implementation of a new care algorithm for palliative care in a neonatal intensive care unit (Conway-Orgel and Edlund, 2015), a nurse-led mobility program in a trauma center (Mount and Anderson, 2015) and the replacement of CVCs with long-term accesses for hemodialysis patients (Mbamalu and Whiteman, 2014).

Having introduced the concepts and the two components of our theoretical framework, the VSM and the 8 steps, we now develop their integration for the purpose of an action-research study.

3. Setting and Methodology

3.1. Context and Research Approach

Our study takes place at Henri Mondor hospital, a French public university hospital, and more specifically in the cancer care division. The cancer division we study contains surgery departments (urology, plastic, digestive), medical departments (hepato-gastroenterology, medical oncology, hematology, nephrology, dermatology) and a radiotherapy department. Its three main specialties are digestive and urology cancers and blood malignancies. In our study, we focus on chemotherapy delivery in cancer care, with the oncology, hematology and dermatology departments. The empirical work was mostly done in the oncology department and the pharmacy department. This is because the processes are assumed to be structurally close in the other clinical departments, and also because the head of the oncology department was most eager to get our input. Therefore limiting the study to the oncology-pharmacy system was relevant because the findings could then be transposed to the dermatology and hematology departments.

During the project, the field researcher spent 18 months as a researcher-in-residence (Marshall et al., 2014) in the hospital, from June 2015 onwards. His overall project was carried in an action-research perspective, in order to improve the efficiency of this cancer division. This paper explains the first cycle of AR where a diagnosis of the organization was undertaken, using the VSM as a framework. The objective of this first phase was to trigger improvement projects and structure a course of action for following phases. This objective in fact concurs with Lewin's first phase of change, unfreezing the present level to introduce changes (1947: 35).

We use action research (AR) as our research design. To describe our approach, we use Checkland and Holwell's framework (1998: 13). Our *area of interest* is that of hospital internal coordination between separate departments. Our *theoretical framework* is a structuralist-functionalist approach to change and integration in organizations, informed by organizational cybernetics, change management and the literature on hospital integration. This framework is embodied in our *methodology* which is the combination of Stafford Beer's VSM and John Kotter's 8 steps. In our case, the mode of AR was "pragmatic action research" as defined by Coghlan and Brannick (2014): we intend to study the system in action, but there is only limited intention at self-study in action from the researcher. Coghlan and Brannick label this approach "internal consulting" or "action learning". Huxham (2003) contrasts these approaches with "varieties that are principally forms of self-development or organizational development". Huxham adds that "the promotion of ideological positions about participation and empowerment that is intrinsic to many of the latter approaches is also not an essential aspect". This approach is also in line with the Design Science stream in OM (Holmström et al., 2009).

To undertake this project, the researcher chose the researcher-in-residence (Marshall et al., 2014) type of engagement. The researcher arrived in the oncology department in a context where discontent was high with current operating procedures: patients experienced long waiting times before getting their treatments, nurses were under stress due to this situation, the oncology department was reaching saturation despite much lower utilization rates than other similar departments, and the pharmacy was drowned under constant calls for last-minute cancellations or prescriptions. The feeling that more integration was needed seemed shared, which agrees with the unitary vision of both the VSM and the 8 steps and gave the researcher the feeling that a structuralist-functionalist paradigm was appropriate during the stages of diagnosis and change program start-up. We now detail the connections between these two models in our methodology.

3.2. The VSM and the 8 Steps in this Project

"Mode 2" Use of the VSM

Despite the fact that action-research is highly participative, the VSM was used solely by the researcher in this project. This is similar to the "Mode 2" of Soft Systems Methodology (SSM) (Checkland and Scholes, 1990), where the researcher uses a Problem Structuring Method (PSM) to guide his own action without explicitly discussing this specific method with his collaborators. This is for instance what Kotiadis does in her "SSM + Discrete Event Simulation" intervention in intermediate care (Kotiadis and Mingers, 2006). Kotiadis and Mingers explain that "the very valuable time that they *[the healthcare professionals]* offered was better spent extracting as much understanding and information about the system rather than explaining the merits of SSM" (2006: 865). In our case too, time was scarce for healthcare professionals, therefore discussions were more operational than modelling-oriented. This is one of the challenges of what has been labelled "Mode 2 research"[6] (Dick, 2014): transdisciplinary means that a common ground must be found between disciplines, which excludes bringing everyone to the same level of knowledge and expertise on every aspect of the project. In our case we feel that mutual trust, shared data and openness on our objectives and vision of the system (that of OM/OR and management engineering) were enough to alleviate the need for a complete training on the VSM. This is why the VSM remained as a mental management model (Schwaninger, 2010) in this study. This point will be analyzed in retrospect in the discussion (Section 5).

Notwithstanding this choice, the results of the analysis were widely shared, and intermediate results (time studies, synthetic reports) were regularly fed back to the professionals. Therefore we are confident that the study can still be labelled as *participatory.* The VSM diagnosis ultimately led to an action plan which is under implementation at the time this thesis is being written. To transform the VSM diagnosis into an action plan, we used Kotter's 8 steps as a guideline.

Coupling the VSM and Kotter's 8 Steps

As demonstrated in the literature review, the VSM is an appropriate tool for the diagnosis and design of organizations. Unlike in product design, organizational design is often all about evolution and not creating from scratch, and like in medicine, it is desirable that cure follows diagnosis. On this point, Beer's writings on the VSM do not offer much to take action: the VSM is a model, not a methodology (Jackson, 2003: 88). Said differently, there is a lot to learn about change content but less about change process in the VSM. To prioritize our actions and handle the organizational change dimension, we build on Kotter's 8 steps.

Combining methods is frequent in OR/MS (Howick and Ackermann, 2011; Munro and Mingers, 2002), and has been theorized inside the concept of "multimethodology" (Mingers and Gill, 1997). Although

[6] The terminology may be misleading here, as Mode 2 refers both to i) a way of using a method in an intervention (Mode 2 of SSM, explained by Checkland) and ii) a way of conducting collaborative, applied research (Mode 2 research).

combining methods can sometimes be challenging, the main problem usually comes from different paradigms being associated (Kotiadis and Mingers, 2006). From this point-of-view, the VSM and the 8 steps can be expected to go along well as they both follow the same structuralist-functionalist paradigm (Hughes, 2016b: 106; Jackson, 2003: 108). The VSM deals with efficiency and efficacy, but it does not tackle the question of effectiveness, i.e. if the goals we pursue really correspond to what we want to achieve. Kotter is all about "needed change", but it does not say much about who defines what is needed. Both are adequate for problems where participants are considered as unitary, i.e. sharing the same values, beliefs and interests (Jackson, 2003: 19). This seems to match the situation (dissatisfaction and desired integration) and our goal (to get a start program going). It is anticipated that this program will later consist of a set of projects which may use different approaches, including more interpretive ones.

Figure 14 proposes the research framework where the VSM and the 8 steps are integrated. The research followed a sequence of data gathering—data analysis informed by the VSM—feeding back data—taking action, in an intervention framed by Kotter's 8 steps. In Figure 14 he researcher is depicted as distinct from the hospital, however obviously relations exist and the Researcher-in-residence is more an intermediate status. In the present case there is no financial tie between the researcher and the hospital, but tied interests, mutual respect and consideration and power games create a bound.

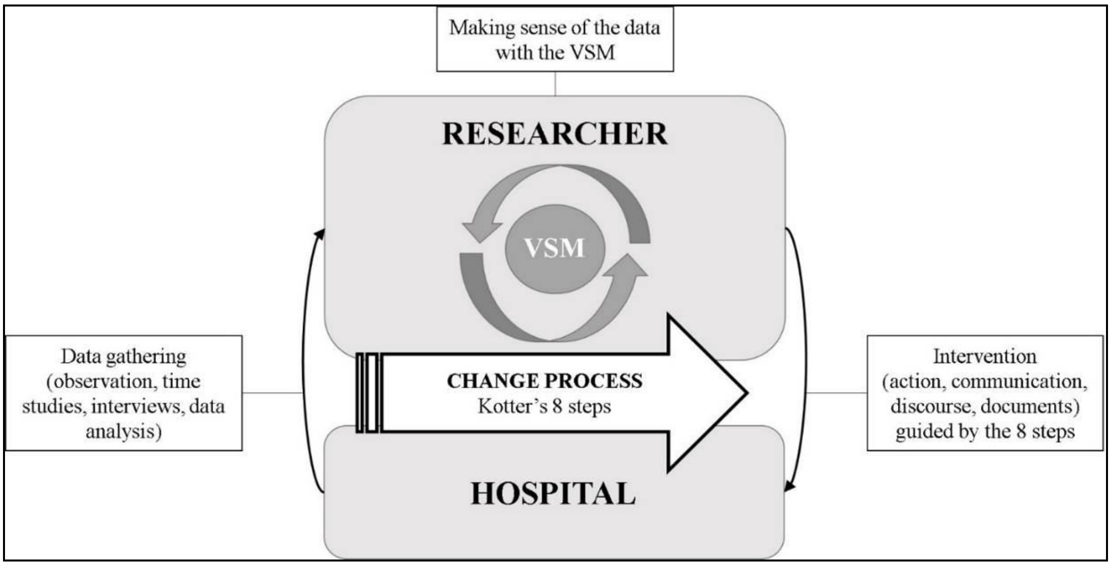


Figure 14 - Research framework integrating the VSM and the 8 steps

Now that the theory underlying our approach and the methodology have been introduced, we present the results of the study.

4. Results

The results are presented in three stages. First, we define the system-in-focus. Second, we analyze it with the VSM. Third, we promote a change process, informed by Kotter's 8 steps.

4.1. Defining the System

Like in any systems approach, the first step is to define the perimeter of the study. In our case, the original assigned perimeter is the outpatient oncology unit in the cancer division. It soon appears too restrictive: we need to include at least one department which is not part of the cancer division, the chemotherapy preparation unit (part of the pharmacy division). A first challenge appears already: the first person that manages both units in the hierarchy is the hospital director. We could decide to set this unit out of our perimeter, and consider it in the environment rather than as part of the system. However, the connections between chemotherapy preparation and chemotherapy delivery processes in hospitals with centralized chemotherapy preparation are so tight (Lamé, Jouini and Stal-Le Cardinal, 2016) that it made more sense to include this pharmaceutical unit. By including the pharmacy, it made sense to also consider two additional departments: the hematology and the dermatology departments, both in the cancer division, because they also deliver chemotherapies to both inpatients and outpatients. We choose not to include imagery and biological departments as the needs for synchronization happen at a longer time-scale. Also, chemotherapy preparation and chemotherapy delivery could hardly survive in the French context as *viable* systems, whereas imagery and biology could. Therefore following Beer's advice (Beer, 1985) we set them aside.

In the end, we have a four-components System 1:

- The outpatient unit of the Medical Oncology department
- The outpatient unit of the Hematology department, and
- The outpatient unit of the Dermatology department, all three in the cancer division, and
- The chemotherapy preparation unit in the pharmacy division.

Figure 15 shows these four components, split between two different hospital divisions. We place our study at the unit level.

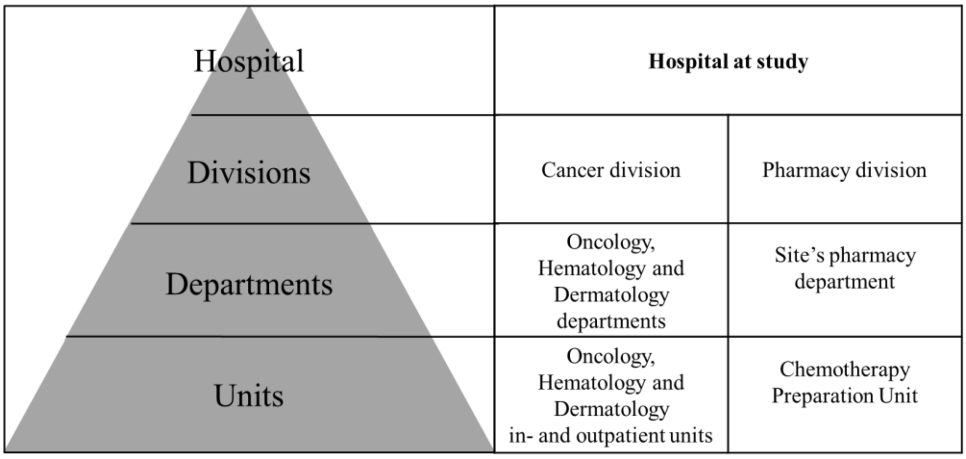


Figure 15 - The divisions, departments and units considered in this study.

In principle, our system-in-focus is typically a high-volume, low-variety service: almost all patients follow the same process, with very few variations besides the type of chemotherapy product. However, in reality, it is experienced by its operators as a typical "organizational mess". This process looks like a good candidate for integration because of the repeatability of the processes (one of the oncologists told us: "outpatient chemotherapy is always more or less the same") and the high volume of patients.

4.2. Diagnosing the System

Now that our system-in-focus is defined, we proceed to the diagnosis using the VSM as a reference model. We analyze all constituting systems of the system-in-focus.

System 1—Production Function

System one of a viable system consists of “those elements that produce it” (Beer, 1984: 14). All four units in System 1 have different environments. They represent different scientific disciplines, each with its scientific societies and body of knowledge. There is also a strong difference between the chemotherapy preparation unit, which is part of the pharmacy and relies on pharmacy decisions for resource allocation, and the three medical departments which are part of the cancer division. This is a clear case where the authority system, “which fits the structure of the organisation” and the responsibility system, “which fits the experience of the patient”, do not correspond (Lehaney and Paul, 1996: 868).

All departments keep a watch on scientific and clinical updates in their respective environment. They appear to be aware of organizational innovations in their respective fields, e.g. patient reported information for medical departments (Kotronoulas et al., 2014) and robot-assisted preparation in the pharmacy (Palma and Bufarini, 2012). Medical departments are in contact with upstream services (surgical services in particular) through Multi-Disciplinary Team meetings, where all cancer cases are discussed.

System 2—Coordination Function

System 2 is a coordination function, it works to smooth the activity between all Systems 1. According to Beer (1984), issues with System 2 being too limited are typical. Coordination is limited to sharing incomplete information, i.e.an incomplete first stage of integration in the framework of Drupsteen et al. (2016). In our case, System 2 is deficient. What happens is that all departments send their prescriptions to the pharmacy, which is the only unit with a view on its production planning. Yet its customers’ performance depend on the ability of the pharmacy to provide them with what they need. The way things are managed during the workday is through a lot of phone calls and faxes to the pharmacy. There is in fact no information shared between the departments that deliver chemotherapies. Processes are defined between the pharmacy and each department and are not connected to one another. As a result the pharmacy workload is highly variable (as much as 50% variation between two days of the same week) and patients sometimes wait hours to get their chemotherapy drugs.

System 3—Control Function and System 3—Audit Function*

System 3 is a function of the “Senior Management” in charge of the *inside–and-now* of the system-in-focus. It is a control function, which allocates resources to System 1 to carry out the instructions of System 4. It translates system-level policies into directives for System 1. It then monitors the performance of System 1 through System 2 and System 3*.

There is no unique entity in the system that performs this function. A small portion of this function is carried by Multi-Disciplinary Team meetings, where patient cases are discussed and collective decisions are made, but these discussions remain clinical and do not cover operational aspects. As far as resource allocation goes, it is performed at two levels: the head of the hospital, where all divisions negotiate for their budgets, and at the division level between departments. However the budget allocation does not consider this system as one, even though the Chemotherapy Preparation Unit as much more connections with its customer departments than with other pharmaceutical units. System 3 should make decisions based on performance measurement. In this case, performance measurement is limited to the evaluation of costs and revenue, and various notions of productivity, and to counting undesired incidents/accidents. There is no fine analysis of the typology of patients being treated and the evolution of this typology. As System 3* goes, audit is mainly on clinical compliance with established guidelines or finances (e.g. activity encoding for refunding) but it is performed by external auditors, mandated by higher hierarchical levels or external organizations. Each department follows up on its activity (number of patients, number of drugs produced), but there is no overall, integrated perspective. There is no routine collection of operational data. Pharmacy follows up on the cost of spoiled drugs, but there is no routine discussion of these figures with physicians. In the oncology department, a first audit was performed on waiting times coming for outpatient chemotherapy. There is no institutionalized systematic problem-solving capacity for the system-in-focus.

System 4—Development Function

The role of System 4 is double. It links the lower levels (the 1-to-3 homeostat) to policy-making System 5, and it captures and analyzes information on the environment of the system-in-focus. It is the place where the internal and external information is integrated. Contrary to the *here-and-now* orientation of System 3, System 4 is described as focused on the *outside-and-then* of the system-in-focus. Jackson refers to System 4 as the "operations room" and the "development function" of the organization (Jackson, 1991: 110–111).

In our case, as mentioned before knowledge is spread around on the organization of outpatient chemotherapy and its best practices, but common discussion is rare. An important missing element is the knowledge of the upstream processes that send patients to the system-in-focus. Where do these patients come from? What is the typology of these patients and why is it so? In oncology there is no report on the number of patients recruited from internal departments (surgery especially) and those coming from external practices.

During the course of the project, the oncology department shifted from a three-year long continuous increase in attendance to a 6% decrease over six months. This was almost impossible to foresee or to explain with the available information. The prospective function is mainly clinical and split on each service, but very limited at the level of the system-in-focus.

System 5—Policy Function

System 5 is where policy is defined, based on the information transmitted by System 4. System 5 is also responsible for representing the system-in-focus to wider systems to which it belongs (in our case, the hospital at large, and then the hospital group). At the time of the diagnosis, we cannot say that there is much policy based on a global view of the system-in-focus. A project emerged a few years back in the cancer division to create a common outpatient clinic for chemotherapy. However this project was based on simple assumptions (a business-as-usual projection), it did not include the pharmacy, and it was never put to work. There is thinking on care pathways for cancer care, but this is across medical and surgical departments – not our system-in-focus.

The representation of the system-in-focus to wider systems is weak. Indeed, there is no integrated consideration when the cancer and pharmacy divisions negotiate their budgets, despite the fact that the units we study in both division depend on each other to develop their activity. If a System 5 is to be defined, then it would be part of the policy-making at the hospital level. Algedonic signals (alerts from the operations in System 1 that go directly to System 5) consist mostly of incidents reported in the dedicated risk management system, and financial alerts (loss of activity in a department).

With this diagnosis established, the objective is to introduce enough changes so as to remove the structural pathologies of the system. To do so, a change process is started.

4.3. Taking Action

The first step in order to take action is to get the change process going and establish a working environment. To do so, we first established a sense of urgency (Kotter's step 1) through time studies and data analysis – thus playing the role of System 3*. To analyze the results and start a collaborative effort, we created a guiding coalition (Kotter's step 2) with the head of the oncology department, the head of the chemotherapy preparation unit, and the head of the cancer division. The vision for the future (Kotter's step 3) is of an integrated outpatient system, with zero waiting time, negligible spoiled drugs and superior efficiency achieved through improved coordination between the units. To communicate the change vision (step 4), we held multiple meetings and presentations: with the heads of the hospital group's pharmacy division and the hospital's pharmacy department, with the director of the hospital, with nurses and nurse assistants in the oncology department, with heads of department from oncology, pharmacy and hematology. The project was also discussed at a strategic seminar for the hospital's heads of divisions and departments.

To empower employees (step 5) and generate short-term wins (step 6) we launched two first improvement projects aimed at solving the problems identified during the diagnosis.

The first project aims at a short-term win and is situated at the operational level. A simulation project was undertaken to analyze potential solutions for the coordination between the oncology department and the pharmacy, at the System 2-System 3 level. The results promoted the creation of a coordination function in the oncology department. Further details are provided in Chapter III. We then put together a small task force meeting every two to three weeks to work on the implementation of this concept. We reviewed the operational use of information systems, modified the use of some software, and changed procedures to take into account constraints of various stakeholders. In this project, the main methods are SSM (Checkland, 1981), Discrete Event Simulation (Jun et al., 1999) and Service Blueprinting (Bitner et al., 2008). Interestingly, this project also contributed to the action plan of a risk assessment in the chemotherapy preparation unit (a project which was started in total independence), where it appeared clearly that analyzing the chemotherapy preparation unit in isolation was not enough to address all identified risks.

The second project takes a more long-term perspective. It addresses the current limitations of prospective thinking in and on the system-in-focus. This is the role of System 4. The main end-point is to decide whether a physical integration of the system-in-focus, as a focused factory (Bredenhoff et al., 2010), is adequate. To make this decision, by-products of the project should include a set of future scenarios to guide the decision, and a finer understanding of patient referral patterns. Who refers them? What is their typology today? How could this situation evolve? These are the questions for this project. To answer them, an approach combining scenario thinking (Bradfield et al., 2005; Van der Heijden, 1996) and medical process data analysis is currently under consideration. At this stage, the use of system dynamics is also a possibility for this long range analysis. The later development of this project is developed in Chapter IV.

Concerning Kotter's two last steps, "consolidating gains and producing more change" (step 7) and "anchoring new approaches in the culture" (step 8), they are implemented progressively. A first gain is the vision that stakeholders have developed of outpatient chemotherapy as a system of prescription-production-administration. We hope to anchor this in the culture through common projects between the involved units. However, these stages take a long time to complete (Pollack and Pollack, 2015) and will require a longitudinal study to be evaluated. In this article, the focus was on launching a change program.

5. Discussion

We have described the project. It is still ongoing, but lessons learned can already be drawn. The first thing that must be done is to evaluate this first stage of the change program. This is an essential step in AR. Then, we discuss the learning drawn from this project. Four areas of learning are developed: the application of the VSM in a hospital, Kotter's 8 steps, the Researcher-in-Residence model and operational factors for hospital integration.

5.1. Evaluating the Project

The last stage in the AR cycle is to evaluate the action taken. Did we change something in the organization? Did we achieve what we wanted to achieve? Are there side-effects? In this case, the initial objective is for the researcher to structure an action plan for a change program, and to start this change program with support from hospital professionals. The objective set to this change program is better integration in chemotherapy delivery.

At the end of the period described in this article, an action plan is proposed and accepted by sponsors. As we write this article, actions have been implemented already, procedures have started to be modified. Meetings have been held with the hospital's direction where the pharmacy and the cancer division have negotiated together for the outpatient chemotherapy system, rather than for each's own interest. The project managed to create a collaboration between the pharmacy and the oncology department, embodied in a series of work meetings. Although before that both departments where cooperative and willing to progress, it was the first time such a collaboration became so concrete. We can therefore say that although operational effects (i.e. measurable impacts, on patient satisfaction or productivity for instance) will only be visible in months to years, when more actions have been implemented, the project has been convincing enough to generate integrated thinking.

A big challenge is the acceptance of the results by a wider audience, in particular at higher hierarchical levels, by the hospital's administrative direction. At the present time encouraging discussions have taken place. The concern is that it may have been more effective to take administrators onboard earlier. However, this may also have created tensions and prevented fruitful discussions with physicians and paramedical staff, which is why it was avoided. Hospital politics are complex, and this is why the project remained at the level of the division to start with.

We now discuss what is learned from this project regarding its methodology and its theoretical framework.

5.2. Specifying Learning

On the VSM and Hospitals

In this project the VSM proved to be a powerful lens to analyze a complex system. It provides a rich thinking environment and a point of comparison for analyzing an organization and constitutes an effective and efficient mental management model to address coordination issues. Literature reviews have noted that multidepartment OM/OR projects are seldom reported in the academic literature (Hulshof et al., 2012; Vanberkel et al., 2009). Based on the experience of this project, the VSM can be a valuable tool to move forward on this dimension. Our conclusion meet with Keating's (2000: 197): analyzing hospital organizations with the VSM "offers valuable insight and understanding of structural adequacy. It is an important first step in effective restructuring or establishing initial operational structure." However, we reiterate that the VSM alone is not enough to guide action. To do so, one can then rely on her own experience, values, skills and instinct, or she can complement them with a change management approach, like Kotter's 8 steps.

On Kotter's change leadership model

This project does not show the full 8 steps. Step 6 is in process, with some short-term wins generated, steps 7 and 8 are still to come. This is not uncommon in applications of Kotter's model (Pollack and Pollack, 2015), and steps 7 and 8, "consolidate gains and produce more change" and "anchor new approaches in the culture", are hard to evaluate (Appelbaum et al., 2012). However, on a small scale, we did consolidate gains on some aspects and anchor them in the operational procedures. An example is a change of posology for chemotherapy premedication, which has been discussed by pharmacists and oncologists, and implemented. This leads us to discuss the linearity and unicity of the 8 steps. On linearity, things in reality are much messier than the neat, sequential 8-step model. There appear to be cycles where a sense of urgency and the vision must be instilled again periodically because day-to-day operations and firefighting take over. Moreover, there are in fact multiple change processes and guiding coalitions at different levels, which Pollack and Pollack (2015) had already mentioned. In our case, there were two instances: a general coalition at the division level, and then a smaller work group at the department level, which elaborated the premedication modification discussed above.

One important critic to Kotter's work is mentioned by (Hughes, 2016a): the depiction of employees as natural resistors to change. We did not come across this type of resistance in our work in the oncology and pharmacy departments. The fact of being integrative, working at a very operational level with frontline workers surely helped. We probably also built on the additional credibility awarded to outsiders, with their "fresh look on the situation", here informed by a curriculum in OM/OR – a discipline no one in the system had notions of. This is congruent with research on "change champions" in healthcare, which are regarded as effective in the first phases of change (Hendy and Barlow, 2012). The fact that the project came with backing from an influent division head, a physician, rather than from administrators certainly helped as well by providing us a status in the organization.

A final remark on the change process is the importance of making connections with other existing projects. In our case, a risk assessment in the pharmacy happened to have similar objectives, so we managed to create synergies, and an extension project in the hospital opened perspectives of layout modifications. Kotter does not mention this aspect, but it proved essential in our project.

Despite these adaptations, we felt that Kotter remained a good guide to start our change effort. It is not a comprehensive cookbook and much still relies on the experience and instinct of the practitioner, but it provides a useful model to get a change program starting. In our case, the first four steps seemed to help "unfreeze" the situation and steps 5 and 6 gave momentum to the initiative.

On the Operations Management Researcher-in-Residence Mode

On a more personal level, this project can be analyzed from the perspective of the Researcher-in-Residence approach it implemented. The Researcher-in-Residence mode practiced in a "problem solving", "design science" way is very demanding since it requires quick reactions to build a methodology "on the go". Holmström et al. write: "design scientists cannot ex ante predict where their research will take them and what the artificial phenomenon or artifact turns out to be. It is the uncompromising commitment to solving the problem—not theoretical or disciplinary consistency—that drives the design scientist. If solving the problem requires changing disciplines in midresearch, the design scientist has no options." (2009: 74). This commitment to solving problems requires a good knowledge of the organization, its context and its culture. As a consequence the Researcher-in-Residence mode in a hospital is very demanding for a PhD student with no past experience in the healthcare sector, but it appears to be the best way to discover and adapt to such a complex context. It requires her to adapt very fast to an environment completely different from other industries. Power games and hierarchical structures are different and arguably more complex. In the present case, the researcher is also confronted with professionals who have very limited knowledge on the sciences of management and organization. In the manufacturing industry, the researcher and her interlocutors often share a common background and culture. In hospitals, clinicians have a completely different approach, often centered on individual patients, diseases and treatments. They have considerable expertise on these fields, but the patient flow, information systems and coordination perspectives are much less developed. A patient pathway view is emerging but remains very constrained by departmental boundaries. Accustomed to matrix organizations and process orientation, the OM/OR researcher must develop a pedagogical approach and defend her trans-departmental approach, in addition to learning about the specific clinical context and the overall healthcare culture and its pluralist organization (Jarzabkowski and Fenton, 2006). The Researcher-in-Residence must also create his own function and build his legitimacy by his usefulness to the organization. This is sometimes a stressful experience.

On the other hand, this mode is also very rewarding. The researcher's knowledge is put to practical use, and if the researcher meets eagerness for improvement, she can work through original approaches and hope to contribute to the implementation of her domain's findings in healthcare. In the context of hospitals, where the techno-structure is very weak, this is a powerful way of concurrently defining a problem, engineering a solution and working through its implementation.

The question that remains is that of the sharing of knowledge between both parties – the researcher and the professionals she works with. In our case, we chose not to train professionals to the VSM. This position is disputable. Openness and transparency are important values in interventional research. So what needs to be specified, what can remain undeclared? Our approach was pragmatic, to raise awareness of coordination issues and the potentialities of an integrated view. At this very early stage in OM thinking entering the system, this was more needed than a detailed introduction to the VSM. It is also difficult for the Researcher-in-Residence to ask for training time in the first stages of his project, and would add significantly more pressure on his shoulders. However, we do not feel that we have been treacherous or dishonest in this project. All raw information was shared. The researcher making sense of this is with his distinct expertise is what is asked from him. The other way around, we felt that we learnt a lot about cancer care, but we in fact learnt just enough to perform our project. No one asked pharmacists or oncologists to unveil the underlying theories when they argued for or against certain propositions. The management of this intermediate knowledge, coproduced during the project, is for us one of the biggest challenges, and definitely a subject for further investigation.

On Integration inside Hospitals

We now discuss Drupsteen et al.'s (2016) antecedents to hospital integration in the light of our project. They identify five antecedents for hospital integration: two inhibiting antecedents, shared resources and uncertainty/variability; two initiating antecedents, process visibility and performance management; and one facilitating antecedent, information technology. They also consider facility layout in their original model but discard it because empirical material does not support it. Regarding these antecedents, our experience suggests the following:

- The shared resource in our case was the pharmacy's chemotherapy production capacity, shared between all the departments that deliver chemotherapy. The fact that the unit is shared is more a problem for the unit itself, which adapts to the procedures of all its "customers", than for the clinical departments.
- Uncertainty/variability was low in our case in terms of the care process, but variations in demand are a challenge. Fluctuating demand from its various customer departments prevents the pharmacy from allocating capacity to each.
- Fragmented performance management clearly appeared to be a barrier, especially when insufficiently informed by the data available in the information system. This is particularly true when resources are needed to manage the interface between departments, which is not visible in the current performance framework.
- Making the process visible, by presenting common projects under the "chemotherapy preparation and delivery" label, raises interest from managers. It is also very clear that presenting to department and division heads the issues of their counterparts, and the impact of their own decisions on their colleagues' work, is a step in facilitating change.
- Information Technology (IT) is already present in the hospital at study that could support integration. Used differently, IT could help, but to re-tune it would require more process visibility and an agreement on integrated performance management. Yet IT could help to manage shared resources, thus alleviating a barrier to integration.

In our case, the time scale is really short: we look at daily operations. Therefore physical integration in the facility layout appeared important because it would limit physical flows and allow for easier instant communication, today performed through fax or telephone. For instance, the distance between the pharmacy and the departments prevents the setting of a quick "morning briefing" (Thompson et al., 2005) to anticipate on the operational issues of the day.

To summarize, our findings concur with Drupsteen et al.'s. We add to their study the fact that when short time scales are considered, facility layout should be included too as an antecedent.

6. Conclusion

6.1. Contributions

In this paper, we presented an action-research project based on Stafford Beer's Viable System Model and John Kotter's 8-Step change leadership process in the context of hospital internal coordination. We justified this combined approach by the fact that the VSM focuses on coordination in complex systems, and that it shares with the 8 steps the same structuralist-functionalist paradigm. We showed that Beer's VSM is a useful tool to tackle such issues on the analytical side, and that Kotter's 8 steps provides an effective guide to start a change program. We underlined certain adaptations to Kotter's model. We also summarized experiential learning on the intervention mode we used, the Researcher-in-Residence mode. This approach is felt as powerful and rewarding, but demanding and needing further clarification on the management of shared knowledge. Finally, we contributed to the literature on operational antecedents to integration in hospitals by reviewing the recent model of Drupsteen et al. (2016) in the light of our empirical work.

6.2. Limits and Further Works

This project bears the intrinsic limits of AR, in particular the theory generated is of limited external validity. To bring more robustness, this project will need to be re-assessed regularly to provide for a longitudinal analysis. It would also be interesting to try analyzing the archetypal hospital organization from the perspective of the VSM. Hospitals share common organizational traits, and a typology of hospitals could be built (public/private, teaching/not teaching, general/focused, large/small, for instance) that could be confronted with the ideal organization offered by the VSM.

An additional point, that we have already underlined, is the need for more research on knowledge sharing, production and management in the Researcher-in-Residence approach. This includes ethical aspects. Following Jackson (1991), critical theory and discourse ethics are one possibility to investigate this aspect.

III. Inter-Department Coordination to Improve Patient Flows in Hospitals[7]

In this chapter, we propose an original approach mixing four methods in order to tackle multidepartment coordination issues in hospitals. The novelty of our approach comes: (i) from the integrative view it takes of the two departments, their interests and their interdependencies; and (ii) from the comprehensive view on the problem solving process. The approach is developed and tested during an action-research project on outpatient chemotherapy delivery in Henri Mondor hospital, a French public academic hospital. Outpatient chemotherapy involves two departments: the outpatient oncology unit, and the pharmacy. The former wishes to minimize patient's waiting times, while the latter needs to minimize the cost of wasted chemotherapy drugs. We take into account the fact that globally optimal solutions may not be satisfactory because of the way accounting and reporting is split across separate units. We also propose a method that mixes the computational power of simulation, with participative methods that allow for the expression of ideas, interests and the negotiation of solutions. Rather than focusing solely on problem framing before simulation, we also support the later stages, once a concept has been chosen with simulation and must be developed into an operational business process. The theory generated is formulated as two design propositions.

[7] Submitted to the *Journal of Operations Management.*

1. Introduction

To meet challenging demands for efficiency, hospitals require approaches that can tackle the interdependence of their components, and address their specific political structure. They need models that can connect departments and manage the coordination of patient flows. Hospitals also need methods that can at the same time provide quantitative, "hard" information for decision-making, and manage the socio-political process of change management. Multiparadigm multimethodology (Kotiadis and Mingers, 2006; Mingers and Gill, 1997), the combination of modelling methods from both Hard and Soft paradigms, is a way forward.

In this chapter, we propose a multimethodological approach to tackle issues of interdepartmental patient flow coordination. The approach is developed and tested during an Action-Research (AR) project in Henri Mondor hospital. The objective of the project is to improve the outpatient chemotherapy delivery process, which involves both the oncology department and a pharmaceutical unit. The main constraint is that the global process must be improved, but in the meantime the performance of individual departments cannot be degraded, otherwise the solution will not be accepted. The approach takes a design perspective on this issue. After defining and structuring the problematic situation using Soft Systems Methodology, the solution space is analyzed by benchmarking other hospitals. The solution space is then reduced using Discrete Event Simulation (DES) to choose a solution concept. This solution concept is refined in Service Blueprinting (SB) workshops.

The outcome of this study is a redefined process that allows for a 20% increase in attendance, while reducing waiting times. This additional activity could yield 400,000 euros in additional revenue, for a cost of 50,000 euros. It is both economically viable, wanted by the staff and desirable from the patient's perspective. The process and its results are appreciated by the healthcare professionals involved. The approach is successful in favoring multidepartment collaboration. It is a useful model for building interventions on issues of patient flows crossing hospital departments. The contributions of this article are framed as two "design propositions" (van Aken et al., 2016): one for outpatient chemotherapy specifically, and one for tackling multidepartment patient flow issues.

In Section 2, the literature on modelling multiple hospital departments and on multimethodology is reviewed. In Section 3, we introduce Henri Mondor hospital and the project which is reported. Section 4 presents the problem-solving methodology and the research approach. In Section 5, the project is described in details. Then the two design propositions are formulated in Section 6. The chapter ends with some concluding remarks.

2. Theoretical Background

This section provides an overview of the theoretical background on the scientific approach in this study. Two research streams are reviewed: the modelling of multiple hospital departments, and the combination of multiple OR/OM methods (multimethodology).

2.1. On Modelling Multiple Hospital Departments

Hospitals are classically formally organized as a set of organ-based departments, supported by functional units such as imagery or pharmacy. An exception to this is the emergency department, which receives patients with a wide range of conditions but all requiring urgent care. However, care processes often involve multiple departments. In the course of her treatment, a cancer patient may need surgery, chemotherapy and radiotherapy. During his chemotherapy, her treatment will most likely involve an oncology unit and a pharmaceutical unit.

In such situations, chances are that opposing interests will emerge. Departments are evaluated on different performance indicators, and have different views on the care process. Therefore actors will tend to find their best interest if there is no incentive to find a common ground and accommodate the competing views (Merode et al., 2002). Often multidepartment issues are also issues where "there is no system owner, and hence no monitoring and control of [the system experienced by patients]" (Lehaney and Paul, 1996): the processes and systems concerned cross different areas of authority.

In the literature, OM/OR papers tackling multidepartment issues, i.e. taking an integrated view on patient care, are rare (Drupsteen et al., 2013; Gunal and Pidd, 2010; Hulshof et al., 2012; Vanberkel et al., 2009). An early examples of an intervention in a multidepartment context is the study by Lehaney and Paul(1996), who use Soft Systems Methodology as a precursor to a simulation model of a system of outpatient clinics and their support processes. Vanberkel et al. (2009) review contributions involving quantitative OM/OR modelling for the period 1999-2008. More recently, Drupsteen et al. (2013, 2016) have set out to explain how hospitals reach integration. Based on multi-case studies on orthopedic care processes in three Dutch hospitals, these studies provide a model of integrative practices that impact patient flow, and of operational antecedents to integration.

Our study is in line with that of van Merode et al. (2002). Indeed, we work on a multidepartment issue, and we take into account the interests of these departments (unit level) while at the same time aiming for global improvement (system level). The theoretical and optimal global solution may not be reached, because it could be that the corresponding organization would reduce the performance indicators of one department. But we seek feasible improvements, in a given performance measurement system, so our approach needs to accommodate this dialogue between the local level and the system level.

2.2. On Multimethodology in Healthcare OM/OR

Multimethodology is the practice, and study thereof, of combining multiple methods from OM/OR in a single intervention (Munro and Mingers, 2002). In this article, we deal with the more specific category of "multiparadigm multimethodology", where methods from different paradigms are combined, for example an interpretive/Soft OM/OR method such as Soft Systems Methodology (SSM) or cognitive mapping with a Hard method like discrete event simulation (DES) or linear programming. Multimethodology is deliberately pragmatic, oriented towards problem-solving. It is an approach akin to Design Science (DS) (Holmström et al., 2009; Romme, 2003; van Aken et al., 2016; van Aken and Romme, 2009). Design Science is a research approach based on pragmatic problem solving, in order to define *generic designs* that can be put to use through a *design* *proposition* (van Aken et al., 2016). In this project, multimethodology is the problem-solving approach we use, and it is studied from a DS perspective.

Multimethodology is not a straightforward practice, especially when "soft" and "hard" methods are combined. Kotiadis and Mingers (2006) review issues that can be met in projects mixing soft and hard methods. They identify cultural and cognitive barriers in multiparadigm multimethodology. Despite these hurdles, many cases of multimethodology are reported in academic papers (Howick and Ackermann, 2011; Pidd, 2012) and by practitioners (Munro and Mingers, 2002).

The practice of multimethodology seems to be gaining momentum in healthcare OM/OR, in particular when it comes to combining simulation with other methods. According to Pidd (2012), "about 40% of healthcare simulation papers report the use of simulation together with another approach". Synergies between SSM and DES have been reported (Holm et al., 2013; Kotiadis, 2007; Lehaney and Paul, 1996; Tako and Kotiadis, 2015), as well as cognitive mapping and DES (Pessôa et al., 2015; Sachdeva et al., 2006). This trend is an answer to the perceived particularities of the healthcare sector regarding the practice of simulation modelling (Tako and Robinson, 2014), including the perceived lack of engagement of stakeholders in the simulation process (Brailsford, Bolt, et al., 2009; Jahangirian et al., 2015). Sachdeva et al. (2006) argue that mixing soft and hard methods increases the potential for implementation. Kotiadis (2007) posits that using SSM as a precursor to DES helps build trust between the modeller and the clients. On the downside, besides the cultural and cognitive barriers identified by Kotiadis and Mingers (2006), Lehaney et al (1999) underline that simulation projects then take longer when a multimethodological approach is taken.

Most authors use Soft methods as a precursor to DES, as Problem Structuring Methods (PSM), in order to tackle the "right problem" (Pidd, 2010). Interest has more recently turned to the downstream stages of refining the concept identified in the simulation and implementing this solution (Kotiadis and Tako, 2016), yet this area is still largely overlooked. Regarding the format of the interventions, both participative modelling in workshops (Baril, Gascon, Miller and Cote, 2016; Tako and Kotiadis, 2015) and more classic approaches with the modeller gathering and processing information (Pessôa et al., 2015) coexist.

In summary, it appears that approaches mixing hard and soft OR, and more particularly simulation and soft OR, are becoming more frequent in healthcare. However, they mainly focus on the upstream phases of a simulation project, i.e. problem structuring and conceptual modelling. In complex organizations, largely driven by the clinical culture, change management is particularly challenging. Therefore it seems important that the later stages of simulation projects be studied too. Moreover, a large part of the literature combines SSM or cognitive mapping and simulation. Many other methods exist that have been overlooked.

In this article, we propose an original approach mixing four methods in order to tackle multidepartment coordination issues in hospitals. The novelty of our approach comes: (i) from the integrative view it takes of the two departments, their interests and their interdependencies; and (ii) from the comprehensive view on the problem solving process. We take into account the fact that globally optimal solutions may not be satisfactory because of the way accounting and reporting is split across separate units. We also propose a method that mixes the computational power of simulation, with participative methods that allow for the expression of ideas, interests and the negotiation of solutions. Rather than focusing solely on problem framing before simulation, we also support the later stages, once a concept has been chosen with simulation and must be developed into an operational business process.

We now introduce the setting in which this method was developed and tested.

3. Problem Description

The study takes places at Henri Mondor hospital, a public university hospital in Créteil, near Paris. Initially, the head of the oncology department worries that his patients are waiting a lot when they come for a chemotherapy. It is perceived as a double problem:

- A service quality problem, as patients have an appointment time but still have to wait;
- A capacity planning problem, as a patient who waits occupies a treatment seat, a critical resource in outpatient chemotherapy. Waiting patients also need nursing attention.

The initial perimeter is restricted to the outpatient oncology unit. The objective of the project is to identify the most efficient actions to reduce waiting times. The initial team consisted of the head of the oncology department, the nurse manager of the department and the external analyst. It was quickly extended to include pharmacists for the chemotherapy preparation unit, because chemotherapy preparation and delivery are closely intertwined processes (cf Chapter I) (Lamé, Jouini and Stal-Le Cardinal, 2016), thus creating a multidepartment issue.

In the process of outpatient chemotherapy, two different flows are synchronized: a patient flow in the outpatient clinic, and a drugs flow coming from the pharmacy. On her chemotherapy day, the patient checks in, waits for her examination, she is examined by an oncologist, and if the doctor validates the chemotherapy she goes to the treatment room. There, her drip is set up, and as soon as the drugs arrive injection can start. If the doctor decides that the patient is not fit for treatment (roughly 10% of patients, congruent with (Masselink et al. 2012) and confirmed by interviews in other hospitals), then she checks-out and goes home. The only exception to that process is a small proportion of patients, around 10%, who do not see the oncologist and go to the treatment room right after checking in. Waiting times occur before medical consultation (24 minutes on average) and between the end of the consultation and the beginning of chemotherapy treatment (1 hour on average).

Concerning chemotherapy drugs preparation, the process is an industry standard. A preparation file is printed, the components are kitted and sent to an isolator in batches of four kits. The batch is sterilized. Then all four preparations can be mixed and are sterilized when they are sent out of the isolator. The drugs are controlled, packed and made available to a logistician. In the morning, this logistician takes the drugs to a counter where nurses come to take them. In the afternoon, the logistician brings them to the oncology department. Transportation is important as two units are located nine floors away from each other.

A major element is the connection between patient flow and pharmacy flow. It has been decided that some drugs (accounting for 86% of the prescriptions) are eligible to advanced preparation and some are not (the most expensive or unstable ones). For the drugs that can be prepared in advance, the pharmacy waits for a confirmation based on blood test results, performed two days before chemotherapy. Preparation is started as soon as positive blood tests results are received and validated by an oncologist. For drugs that can't be prepared in advance, because they are too expensive or have too short stability delays, the oncologist confirms only after seeing the patient on chemotherapy day. This preparation policy has obviously a great impact on patient waiting times. Of the 86% of the prescriptions that are eligible for advanced preparation, only 25% are prepared earlier than on treatment's day. The risk when preparing drugs in advance is that the patient will ultimately not be in sufficiently good condition for her treatment and the drugs have to be disposed of, which represents a net loss.

At the system level, a solution reducing global costs and waiting times would be acceptable. However, the budgets and management structures of the pharmacy and the outpatient department are separated. Therefore, a solution that would create more revenue mainly in the outpatient department while generating more costs mainly in the pharmacy would not be feasible. This is why we must take into account both the system's level and the unit level. The objectives are to reduce patient waiting times (outpatient chemotherapy unit), while not augmenting or reducing the cost of wasted drugs. What processes can be modified to allow for this, and how? Should the procedure for advanced preparation be modified and how? What would be the impact on the pharmacy and the outpatient department? Would this be acceptable for pharmacy and oncology workers? For the patients? These are the questions that need to be addressed.

4. Proposed Methodology

To tackle the issues presented above, the required method should:

- Be pragmatic, oriented towards improvement of operations
- Accommodate multiple viewpoints: patients, physicians, nurses, pharmacists
- Be patient-focused, i.e. put the patient's expectations and needs before the organization's
- Offer sufficiently "soft" insights to tackle the political and social dimensions
- Provide quantitative analysis to allow a preliminary assessment of the impact of proposed changes and a discussion with administrators if resources are required
- Given our practical constraints, the method should also be flexible enough to be implemented by one analyst/facilitator working with a team of professionals

To the best of our knowledge, no off-the-shelf method promises to address all these issues. However, there are methods that tackle portions of our problem. During our project, we have identified four: Soft Systems Methodology (SSM), benchmarking, Discrete Event Simulation (DES) and Service Blueprinting (SB). What appears to be the most efficient way forward is the combination of these methods, rather than a new development. Methodological combinations are not without challenges (Kotiadis and Mingers, 2006), yet the potential is huge, and successful projects have been reported (Howick and Ackermann, 2011). We next describe the four methods individually. Then, the way the four methods are combined is developed. Finally, we present our research approach, based on Action Research to develop and evaluate design propositions.

4.1. Soft Systems Methodology

SSM is an action-research framework developed since the 1970's, with a long history of applications (Checkland and Scholes, 1990). It starts from a "problem situation", perceived as such by a set of dissatisfied people. From this problem situation, SSM has two streams of enquiry. First, a stream of logic-based enquiry, where the situation is modelled as a set of relevant systems of connected tasks and issues, which can be compared to the real-world situation. Second, a stream of cultural analysis, where the intervention is analyzed from the social (norms, values, roles) and political (power) perspectives. These two streams rejoin to identify systemically desirable and culturally feasible changes aimed at improving the problem situation. Figure 16 provides the classic seven-stage schematic model of SSM.

SSM can be used in Mode 1, as a step-by-step, explicit method to do the study, or in Mode 2, as a systemic framework to reflect on a project as it progresses (Checkland and Scholes, 1990). In Mode 2, the facilitators think of the situation in terms of SSM but do not necessarily make SSM explicit to other members of the project.

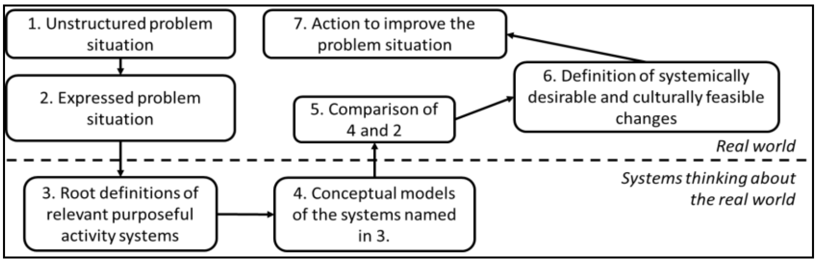


Figure 16 - Seven-stage model of SSM, adapted from (Checkland and Scholes, 1990)

4.2. Benchmarking

> *"The essence of benchmarking is the process of identifying the highest standards of excellence for products, services, or processes, and then making the improvements necessary to reach those standards – commonly called "best practices"."* (Bhutta and Huq, 1999: 254)

There are different types of benchmarking, which is basically a comparison of one's organization's performance to the best-in-class. In our case, the best type of benchmarking is process benchmarking, where "methods and processes are compared in an effort to improve the processes in our own company." (Bhutta and Huq, 1999: 257).

4.3. Discrete Event Simulation

> *"[Discrete Event] simulation . . . is used for modelling queuing systems. These consist of entities being processed through a series of stages, with queues forming between each stage if there is insufficient processing capacity."* (Robinson, 2004: 11)

In DES, the operation of complex systems is modelled as a sequence of discrete events. At each event, an entity in the system changes its status. In particular, entities move from one location to another, e.g. by being processed by a machine or transported by an operator. A screenshot from the DES software ARNEA is provided in Figure 17. A set of interconnected boxes, representing process steps, is visible. Entities have accumulated before the box labelled "Match 1", where they wait to be processed.

DES is a well-established approach for analyzing the performance of manufacturing and service systems, including healthcare (Gunal and Pidd, 2010). DES allows the modeller to define different scenarios and picture the behaviour of the system in each one of them. It allows for the definition of various quantitative performance indicators.

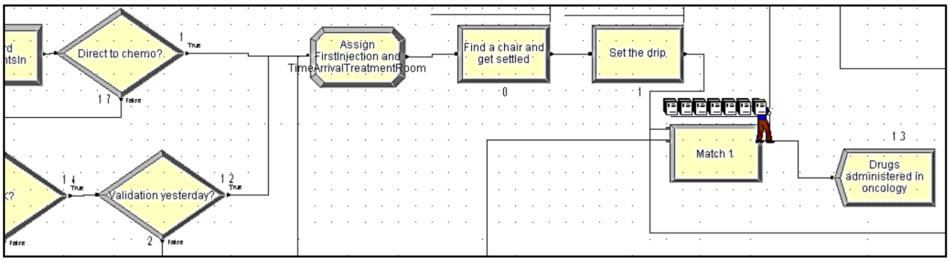


Figure 17 - Screenshot of ARENA, the DES software used in this study

4.4. Service Blueprinting

SB is a method for creating activity-based models of services, first presented by Shostack (1984). It has some features which makes it especially fit for modelling services:

> *"In comparison to other process-oriented design techniques and tools, service blueprints are first and foremost customer-focused, allowing firms to visualize the service processes, points of customer contact, and the physical evidence associated with their services from their customers' perspective. Blueprints also illuminate and connect the underlying support processes throughout the organization that drive and support customer-focused service execution."* (Bitner et al., 2008: 67)

Figure 18 shows how service blueprints are structured. An example of SB use in healthcare is (Maurer et al., 2011).

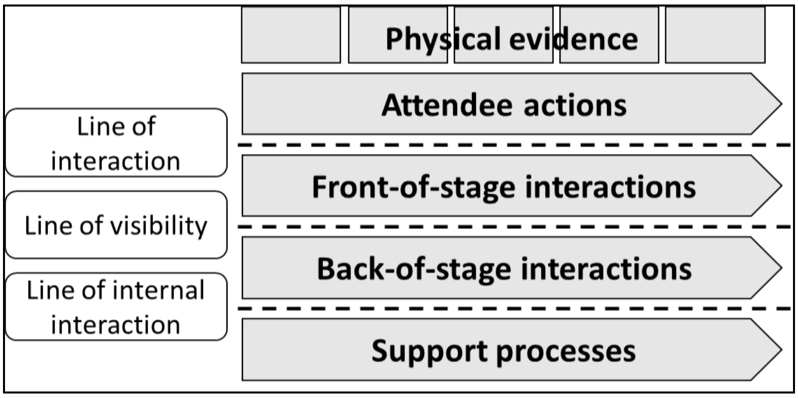


Figure 18 - The model for service blueprints

4.5. Coupling the Methods

Table 1 presents the individual advantages of each method, their limits, and to what end they are used in our multimethod. All methods have their weaknesses and their strengths, and we combine them hoping that each will complete the others' deficiencies.

We organize the methods as a design process. It goes from diagnosing setting the project's perimeter to identifying promising concepts, to developing them into a detailed solution. Figure 19 provides a sequential view of the different tools and methods in our global method. It can be seen as a variant or an extension of Holm et al.'s multimethodology (2013) which combines SSM and DES: we go further in the process as we tackle detail design with a dedicated tool.

Table 5 - The four methods combined in our approach

Method	Individual advantages (in our context)	Individual limits (in our context)	Use in our method
SSM	Complete action-research framework Systemic: multiple dimensions (social, political) Interpretive: multiple viewpoints	No quantitative dimension	As an integrative framework (in mode 2 in our example)
Benchmarking	Brings external knowledge Helps to appreciate one's performance	No guarantee on the transferability of practices Difficulty to obtain data	Identify good practices, gather solution concepts
DES	Quantitative Allows scenario testing Allows animation	Conceptual modelling is much of a craft Data intensive "Black box" modelling	To validate a concept for a solution
SB	Customer/Patient-focused Cross-department: links all activities regardless of organizational boundaries	No quantitative dimension	To design the details of a solution

The status of SSM in this approach is different from that of other methods, as we use some SSM tools in the beginning of the project (during diagnosis), but SSM is also used as a framework for the whole project. SSM provides a “mental model” for thinking the intervention and maintaining the different perspectives in the facilitator’s mind.

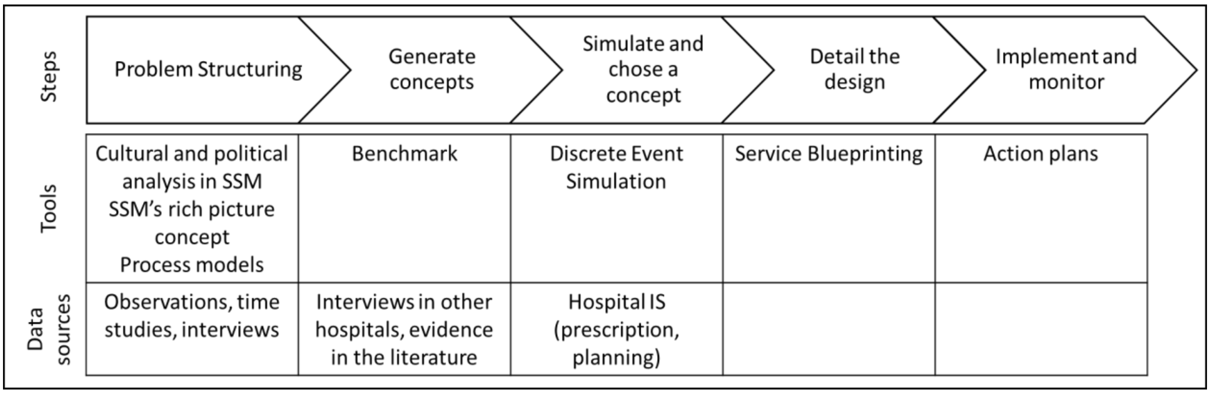


Figure 19 - Sequential view of the method

4.6. Research Approach

The method was developed and tested during an action research (AR) project (Coghlan and Brannick, 2014), with the modeller involved as a Researcher-in-Residence (Marshall et al., 2014) in the hospital. AR is an interesting approach to develop and test design propositions in DS (Holmström et al., 2009). Indeed, as Cross puts it, “Design knowledge is of and about the artificial world and how to contribute to the creation and maintenance of that world. Some of it is knowledge inherent in the activity of designing, gained through engaging in and reflecting on that activity.” (Cross, 2001: 54)

Checkland and Holwell (1998) proposed a model to describe AR projects, the *F-M-A* model, standing for the (theoretical) Framework, the Methodology and the Area of interest of the project. This framework was later extended by McKay and Marshall (2001) to distinguish between the Research Methodology M_R and the Problem-Solving Methodology M_{PS}, and between the theoretical Area of interest *A* and the practical Problem situation *P*. In our case, we have:

- *F*: a design approach with combined quantitative and qualitative methods is promising to solve patient flow issues that involve multiple hospital departments
- M_R: action research
- M_{PS}: the multi-method presented above
- *A*: coordination of patient flows that cross multiple hospital departments
- *P*: outpatient chemotherapy delivery in a French public university hospital

Figure 20 provides the chronology of three AR cycles performed in this project.

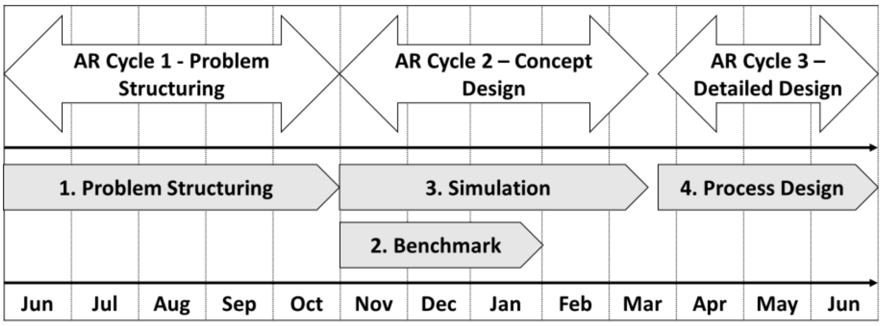


Figure 20 - Chronology of the project

5. Narrative of the Case Study

We now present the project led in Henri Mondor hospital. It is described in three main stages: problem structuring, concept design and detailed design.

5.1. AR Cycle 1—Problem Structuring

The first phase in the project was a problem-definition stage of the system studied. It started with a definition of the chemotherapy delivery process, based on interviews and numerous observations. Further details on the observation protocol and the intermediate results it yielded can be found in (Lamé, Stal-Le Cardinal, et al., 2016). Time-studies helped to understand the performance of the system and to associate quantitative measurements to the logic-based enquiry in SSM. Patients wait on average 24 minutes before their medical examination, and then another 60 minutes before starting their chemotherapy treatment. In parallel, systems of interest were identified and modelled as purposeful activity models along several perspectives: the patient, the oncologist, the nurse, the pharmacist. Figure 21 shows a consolidated conceptual model.

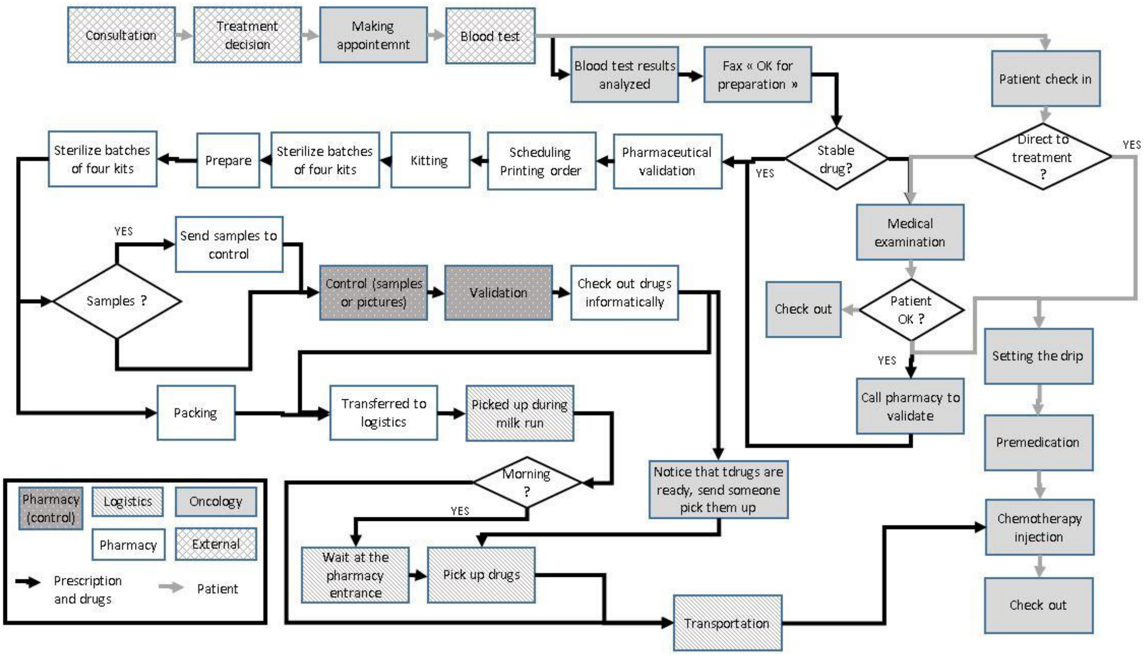


Figure 21 - Conceptual model with the perspectives of different agents

It appeared from this first observation that the main cause of patient's waiting times was that nurses had to wait for chemotherapy drugs to be prepared and transported to the unit before starting infusions. A systematic literature review was conducted on outpatient chemotherapy planning (Lamé, Jouini and Stal-Le Cardinal, 2016), from which it appeared that few papers addressed what appeared to be the main issue in our hospital: the coordination and synchronization between the prescription and administration of chemotherapies in the outpatient unit, and the preparation of the drugs in the pharmacy. Consequently, the protocol of observation and interviews was extended to the pharmacy.

At this stage, SSM provided a method for defining and analysing different systems, which model the same real situation from different perspectives. Also important, SSM provided a lens to analyse the social and political dimensions of the situation. The different professional cultures in the pharmacy and the oncology department, the position of the chemotherapy preparation unit as a "support function" for medical departments proved to be important elements for the rest of the project. Figure 22 shows three CATWOE definitions elaborated during this stage by the modeller, for his own understanding of the situation. "Pharmacy 1" and "Pharmacy 2" show how a similar unit can be seen from different perspectives. The real pharmacy actually works a lot like Pharmacy 1 (support function, drug production unit), and would like to be more like Pharmacy 2 (part of care). "Project" is a CATWOE definition of what the project is aimed at.

Pharmacy 1	Pharmacy 2	Project
C – Departments that prescribe chemotherapies	C – The patients who require chemotherapies	C – Head of oncology, head of pharm. Unit
A – The pharmacists and their assistants	A – The pharmacists and their assistants	A – The modeller, head of oncology, head of pharm. Unit
T – Prescriptions → Drugs	T – Prescriptions → Drugs	T – Insufficient coordination → New coordinated procedure
W – The unit is a « support department » for clinical departments who deliver chemotherapies	W – The unit performs part of a care process centered on patients' care and wellbeing	W – Systems thinking and OM/OR can help improve hospital organization
O – The hospital's director	O – The hospital's director	O – The division's head, the modeller
E – Budgetary constraints, regulations on handling cytotoxics	E – Budgetary constraints, regulations on handling cytotoxics	E – Time constraints, modeller alone

Figure 22 - Three examples of root definitions (CATWOE) elaborated during AR Cycle 1.

In the end, the results of this first analysis were presented to the staff of the oncology unit and the pharmacists, and a team was set up with the head of the oncology department and the pharmacist responsible for the chemotherapy preparation unit. It was decided that the analyst would build a simulation model, and visit other outpatient chemotherapy units to look for good practices.

5.2. AR Cycle 2—Concept Design

In the second cycle, two tasks were carried in parallel: modelling and simulating the system, and gathering solution concepts from other organizations. The model was built iteratively and validated using multiple methods: comparison of the results with time studies, internal (conceptual) validation and animated running of the model with physicians and pharmacists. More details on the simulation model can be found in (Lamé, Jouini, Stal-Le Cardinal, et al., 2016) and in Appendix A (which provides an alternative view of the conceptual model, the distribution laws for each process, and the validation methods).

Concerning the benchmark study, the analyst met with six people from four different hospitals. All were keen on sharing their experience and discussing the way they managed their outpatient chemotherapy process. Most did not have a performance measurement system in place at the operations level, therefore discussions were mostly qualitative on the improvements experienced and the process of developing and implementing new procedures. Three concepts emerged from this study:

- Getting information on the patient's status before she comes for her chemotherapy, so that drugs can be prepared in advance
- Preparing standard, rounded doses of chemotherapy, using a Make-to-Stock (MTS) rather than Make-to-Order (MTO) policy
- Acquiring a robot for chemotherapy preparation

These solutions, and some other suggested by interviewees but not implemented in their hospitals, are summarized in Table 6. The individual impact is that reported by interviewees or the literature. Question marks indicate solutions for which we had no example of the solution implemented in isolation from other solutions. In particular, we did not meet people who used pneumatic tubes for chemotherapy transportation, without getting advanced confirmation on patients' status.

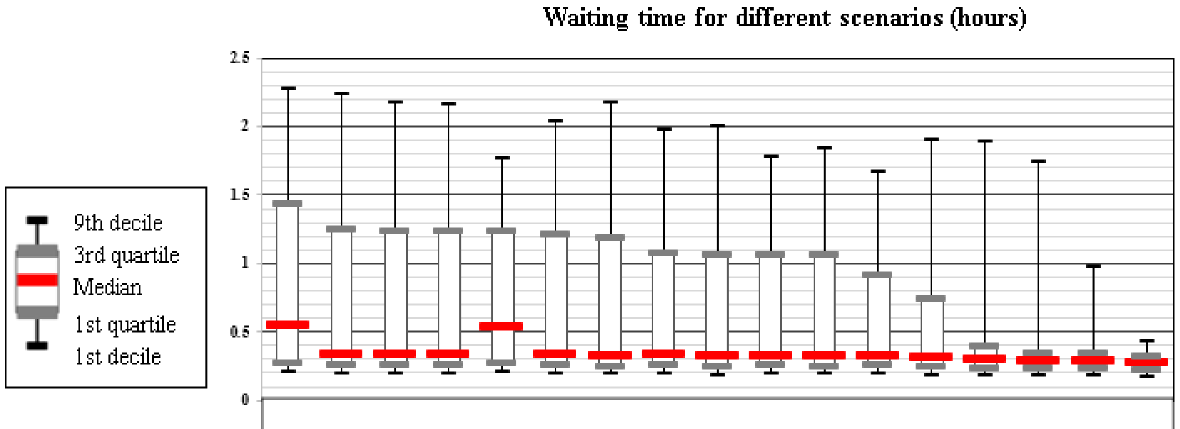
Some solutions were already eliminated. Having the medical consultation on treatment's eve is against regulations in France, as an outpatient chemotherapy session should include a medical consultation. Using pneumatic tubes for transporting outpatient chemotherapy would require to develop a pneumatic network, besides this solution is discouraged in some recommendations (Easty et al., 2014). Three of the solutions (dose banding, advanced confirmation of patient status, consultation on treatment's eve) work on a same solution principle: increasing advanced preparation. This principle was tested in the simulation model against an increase in transportation resources, a modification in work schedules and the addition of resources at various steps in the process.

Table 6 - Solution concepts identified in the benchmark

Solution	Strengths	Weaknesses	Ref.
Dose banding	Pharmacy can smooth its workload	Needs storage space (currently unavailable) Does not apply to all products Only good for large pharmacies	(Pouliquen et al., 2011)
Advanced confirmation of patient status	Allows advanced preparation of chemotherapy drugs	Cost: a nurse is needed to contact patients and process the information	(Berhoune et al., 2010)
Add resources to existing process	If manpower is the limiting resource, will relieve the bottleneck	Operating cost	
Transport drugs through pneumatic tubes	Reduces transportation cost and delay	No pneumatics today, so investment is necessary Drugs occasionally get damaged	(Easty et al., 2014)
Robotized chemotherapy preparation	Reduces repetitive strain injuries during preparation Robot replaces an assistant: reduced operating costs	Investment cost No impact on delays can be expected without changing the prescription process	(Palma and Bufarini, 2012)
Modify work schedules	No cost	Anticipated resistance	
Patient consultation on treatment's eve	Allows advanced preparation of drugs with almost 100% certainty on the patient's status	Impossible in France: transportation costs would double and an additional consultation would be billed	(Dobish, 2003)

The simulation study proved that the most promising solution is the advanced preparation of drugs. The results of the comparison of scenarios are shown in Figure 23. When looking at the 3rd quartile of patient waiting times, only four scenarios offer significant improvement: the same process, but with at least 70% of advanced preparation. However, improvements seem limited when, while keeping a list of 84% of the products eligible for advanced preparation, one increases effective advanced preparation from 70% to 100%. To clarify the impact of advanced preparation, Figure 24 shows how waiting time decreases as a function of advanced preparation, for lists of respectively 84% (left quadrant) and 95% (right quadrant) of the prescriptions eligible to advanced preparation. For a given repartition indicator, for instance the 3rd quartile, the value decreases until reaching a threshold of

20 minutes, which will include some nurse work and the time for the patient to get settled in the treatment room. For the third quartile, this threshold is reached at 70% of advanced preparation with a list of 84% of the prescriptions, and at 50% of advanced preparation for a list of 95% of the prescriptions eligible. This study shows that aiming at 100% of advanced preparation is not necessarily relevant.



% eligible to advanced preparation	84	84	84	84	95	84	84	84	84	84	84	95	84	84	84	95	95
% of eligible effectively prepared in advance	10	25	25	25	10	25	25	25	25	25	25	25	25	70	100	70	100
Scenario for resources and organization	B	Sch	B	C	B	I	N	Sch Pr	Pr	I Ph	Ph	B	T	B	B	B	B

B: baseline; Sch: new working schedule in the pharmacy; C: 5 additional treatment chairs; I: additional isolator; Pr: additional pharmacy dispenser; T: additional morning transporter; Ph: additional polyvalent resource (preparator and pilot) in the pharmacy

Figure 23 - Evaluation of scenarios

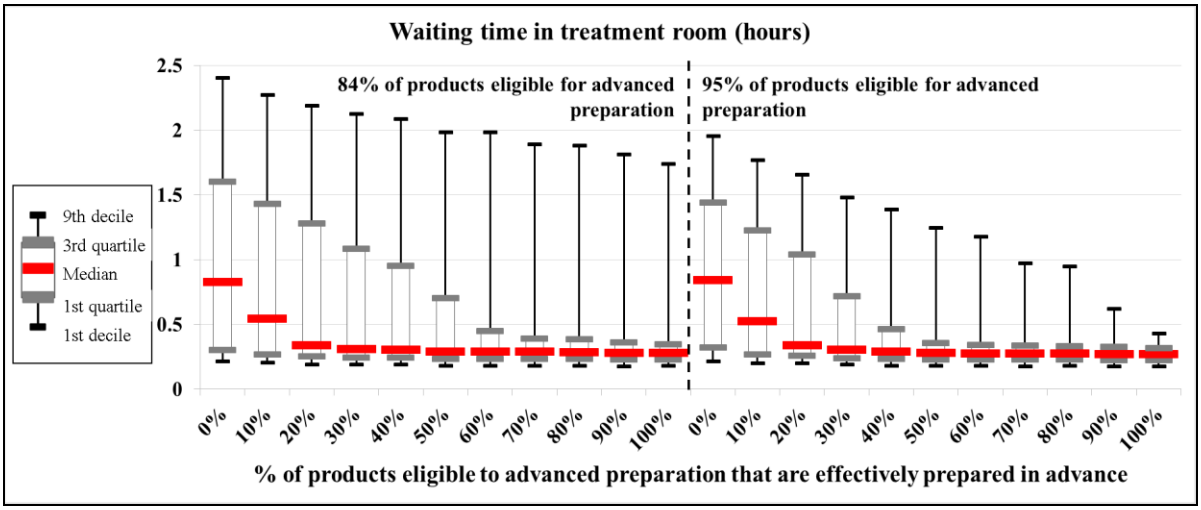
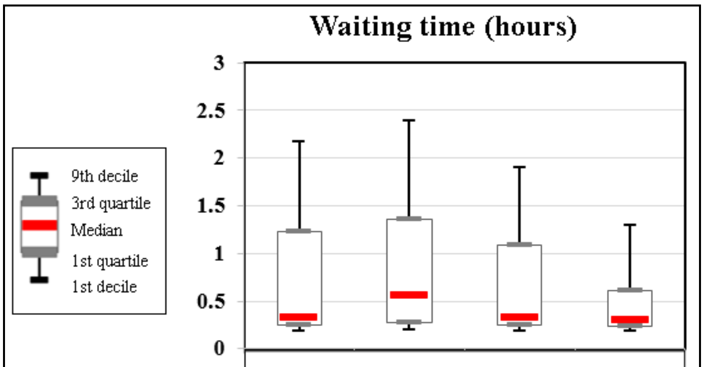


Figure 24 - Impact of advanced preparation on patient waiting times

Moving inside each quadrant of Figure 24 is not the same thing as moving from the left quadrant to the right. Inside one quadrant, the issue is to be able to prepare in advance, i.e. to have the required resources, including information, to do so. From the left to the right quadrant, a reevaluation of the financial risk of expanding the list of eligible products is needed. A sensible course of action is to start by increasing the level of effective advanced preparation, evaluate the impact, and then expand the list. This means first reaching 70% of advanced preparation with the current list, and then moving from 84% of the prescriptions eligible to 95%. The 70% value of effective advanced preparation has been determined because it could bring 75% of the patients below 20 minutes of waiting time, which seemed to be a good first step to the project team.

Two concepts allow for the increase of effective advanced preparation: dose banding, and advanced acquisition of information on the patients' status. In our case, there is not enough storage capacity to allow for MTS chemotherapy drug production, and the variety of prescription seemed too high to allow for a good MTS policy. Indeed, the hospital cares for a wide range of cancer patients: digestive, breast, urology, which means that many different products are prescribed. In addition to the storage problem, which would have been difficult to solve on a short delay, the team estimated that the prescription pattern was not repetitive enough for applying dose-banding widely.

Consequently, we went for the second solution, getting advanced confirmation of the patient's status. As shown in Figure 25, the simulation study proved that this concept could allow a 20% increase in the number of sessions held each year, which represents 400,000 euros in revenue. The estimated cost is one additional nurse dedicated to the gathering of patient information and its transmission to the pharmacy in a timely manner. This concept was by far the most effective (75% of the patients have less than 35 minutes between their medical appointment and their chemotherapy infusion, as opposed to 1h15' today) and efficient (400,000 euros in additional revenues, with a cost of 50,000 euros). This is the concept that was chosen to be studied forward.



Attendance	Baseline	+20%	+20%	+20%
% eligible to advanced preparation	84%	84%	84%	95%
% of eligible effectively prepared in advance	25%	25%	70%	70%

Figure 25 - Effect of advanced preparation with a 20% increase of the number of patients.

5.3. AR Cycle 3—Detailed Design

To transform a broad concept into a new procedure, we used Service Blueprinting. Three one-hour workshops were organized with nurses, oncologists and pharmacists. During these workshops, many constraints were elicited and discussed: IT systems, working schedules, costs, etc. Peripheral problems where identified and tackled, which permitted quick changes to be made in the process (for instance, to re-communicate to all patients the dates for their blood tests, to have the blood tests made earlier, or to shift premedication from IV to oral). This allowed for the definition of a service blueprint for the new organization of chemotherapy prescription, mixing and delivery. The main steps of this blueprint are presented in figure 26.

Even after this stage, the system was not totally defined. A choice remained on the technical means to contact patients. Should it be a synchronous process, by phone, or asynchronous, with patients filling in questionnaires on a web-application? Both possibilities are being investigated, knowing that some patients will not be able to use smartphone or web apps, so phone calls will remain part of the solution.

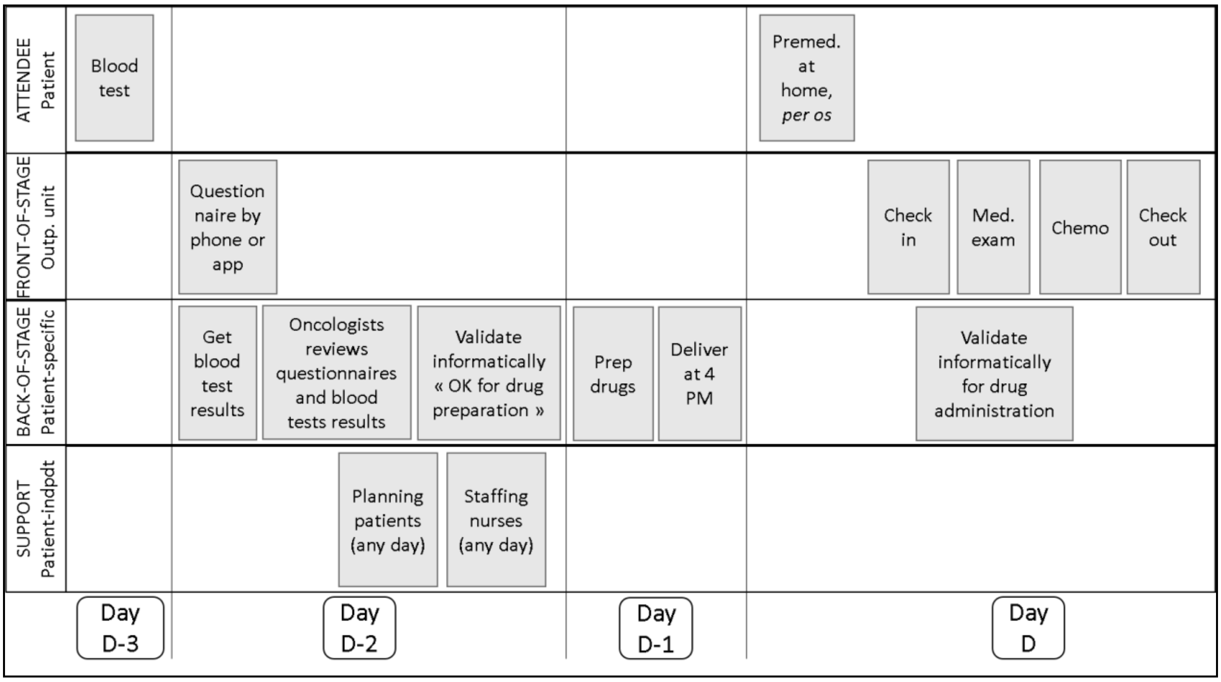


Figure 26 - Main steps in the blueprint for the redesigned process

5.4. Next Steps in the Project

As an agreement has been reached on a concept which was developed up to an operational solution, the next stage is to implement the new process. At this stage, the redesigned process is supported by the two department managers, the medical and nursing staff and by the pharmacy. Some changes discussed in the project team and in the SB workshops have been implemented, e.g. switching the premedication from IV to oral, having patients get their blood test three days prior to their chemotherapy, and developing the questionnaire. A project has been launched to develop and evaluate an application. Concurrently, a phone-call solution is being considered for those patients who have no smartphone. The hiring of an additional nurse is being negotiated with the administration. However, it is subject to the hiring schedule and the recruitment procedure in public hospitals. The project has been the occasion to question existing arrangements, to highlight the dependencies between the departments and to work on a solution agreeable by all.

6. Discussion

We have presented the different steps the project went through, from the initial problem-framing stage to detailing the changes to be made to the process. We now formulate the knowledge created in this project as two design propositions. The first one is about the solution concept we chose, and the second one is about the problem-solving methodology. For each we detail the proposition, its domain of validity and its generating mechanism.

6.1. First Design Proposition

Proposition

Our first design proposition deals with the solution concept that was developed for outpatient chemotherapy management. The *generic design* (van Aken et al., 2016) can be expressed very simply: the idea is to obtain information on the patient's status before she comes to the hospital, in order to reduce her length of stay. Our design proposition is as follows:

> *"When trying to reduce patient waiting times in outpatient chemotherapy units, if these waiting times are due to untimely delivery of chemotherapy drugs, then contacting patients prior to their chemotherapy to enquire about their status is a concept of interest since it allows advanced preparation of chemotherapy drugs."*

Validity and Scope of Application

This concept is not new: Its pragmatic validity has been validated at Hôpital Européen Georges Pompidou (Berhoune et al., 2010, 2011; Scotté et al., 2013). Our study is therefore what van Aken (2004) refers to as β-testing this concept, which we perform with simulation and theoretical design. The potential implications are important: every year, about 650,000 Americans receive outpatient chemotherapy (Halpern and Yabroff 2008).

Generating Mechanism

As for the generating mechanism that makes this solution effective, we can analyze it with Theory of Constraints (Goldratt and Cox, 1989; Gupta and Boyd, 2008): what limited the capacity of the process to reach better performance was the unavailability of timely information in the pharmacy. This prevented advanced preparation of chemotherapy drugs, and generated waiting times due to the inherent inflexibility in chemotherapy mixing procedures. The mechanism is similar to the one in Single Minute Exchange of Dies (SMED): do as much as possible outside of the "value added time window", in the present case, do as much as possible before the patient arrives. And in order to do this, information is needed. A similar principle is used when customers order their meals on a web app before picking them at a fast food restaurant. The difference with outpatient chemotherapy planning is that the hospital makes this anticipated step mandatory, and it is the hospital and not the patient who takes the initiative of gathering information.

6.2. Second Design Proposition

Proposition

Our second design proposition is methodological. Its generic design is embodied in the method presented in Section 3.5 for tackling issues of patient flows that cross multiple departments. We derive the following design proposition:

> *"In a case where, in a hospital, multiple departments are routinely involved in care delivery for a defined group of patients, and patient flow management is perceived as deficient, the proposed method is a way to define and agree upon a shared solution between the departments."*

Validity and Scope of Application

In this project, we show that this design proposition allows to reach an agreement between two hospital departments with different interests but involved in the same flow of patients. We have no reason to believe that the method could not apply to other multidepartment coordination issues in hospitals.

However, this study addressed only the medical and paramedical population. As pluralist organizations, hospitals (especially public ones) deal with diverging viewpoints and interests from a more diverse range of internal and external stakeholders (Jarzabkowski and Fenton, 2006). An additional layer of complexity is added when one involves the administration, and we reach yet another level of complexity if patients are involved. This proposition is in the first steps of Holmström et al.'s (2009) model for theory generation in DS. Further research should especially be conducted to incorporate administrators and patients in similar interventions.

Generating Mechanisms

Although one cannot prove a methodology (Checkland, 1981), we can hypothesize on what makes this one effective. Why does the method help to reach an agreement between hospital departments? We offer two potential generating mechanisms.

First, the method mixes interpretivist and unitary methods (Jackson, 2006). Therefore, it allows for the elicitation of "brutal facts" (Cuccurullo and Lega, 2013) while allowing for the accommodation of multiple viewpoints. This is one of the strengths of *multimethodology*, the combination of methods from different paradigms into one single intervention (Kotiadis and Mingers, 2006; Mingers and Gill, 1997). Along with Kotiadis (2007) and Pessôa et al. (2015), we feel that using a Problem Structuring Method to start the intervention (SSM in our case) helped build trust with both involved departments. Although SSM is labelled "Soft OR", the quantitative aspects of the problem structuring stage (time studies, data analysis from the hospital IS) were also greatly appreciated. Benchmarking and simulation shared the role of experimenting, be it through the experience of others or through a computer model. Visiting other similar departments in other hospitals allowed us to identify the key points in the choice of concepts, and it reinforced the confidence in the study. Simulation allowed to transpose the experience of others in the specific context of the project. It was also a key element in the economic analysis of the different concepts: it largely embodies the "accountant's vision" of the project. Finally, most multimethodological frameworks involving simulation focus on the earlier stages of the project. In our case, the detailed design stages proved to be very important. Many practical hurdles were discovered at this stage that could have stopped the project. This was also the only stage where we held formal workshops. Because more people were involved, especially frontline staff (nurses and pharmacy assistants), new improvements were also proposed that had not been identified before. By increasing the level of detail, this stage allows for precise, practical discussions to happen, which is not possible at the conceptual design stage.

A second strength of this approach is that the method progressively reduces the solution space, and does not eliminate solutions until they are clearly outperformed or declared undesirable by participants. This is akin to Set-Based design, as opposed to point-based design, in mechanical engineering (Sobek, II et al., 1999; Ward et al., 1995). In point-based design, one concept is chosen as soon as possible and is then refined. In set-based design, decisions are made as late as possible in order to keep the design space as open as possible. This is what we tried to do every time it was possible. This behavior gives more flexibility and robustness to the approach and reduces the risk of failure when unidentified constraints surface after a decision has been made to develop one concept at the expense of all others. We eliminated solutions when they were clearly undesirable or unfeasible in our context. Yet after the detailed design stage, two options were still open to implement the improvements: calling patients on the phone or using a smartphone app. Both are being investigated further and will be experimented to make a final decision.

7. Conclusion

In this paper, we have presented the results of a DS project in a French public university hospital. The project dealt with the outpatient chemotherapy delivery process, between the oncology department and the pharmacy department. We have developed and tested a method to improve coordination between hospital departments which share patient flows, but are highly independent from other perspectives, especially regarding financial accountability. The method combines elements of SSM, DES, benchmarking and SB. It allowed for the preemptive testing and conceptual validation of a solution concept for improving the efficiency of outpatient chemotherapy planning. The problem-solving approach we used and the solution concept are formulated as design propositions, and their validity is discussed. Future research should focus on the integration of a wider population in the study, starting with hospital administrators, and then patients.

IV. A Systems Approach to the Challenges of Strategic Planning Academic Medical Centers[8]

Public Academic Medical Centers (PAMCs) have long been described as complex organizations. This is presented as the reason why strategic planning often fails in PAMCs. Yet this complexity has not been qualified. This is what this article aims at, using systemic modelling. Our data is based on empirical work in Henri Mondor hospital, a French PAMC, and on regulatory constraints in French PAMCs. We propose a qualitative system dynamics model of hospital operations, and a dependency structure model of PAMC governance. Thanks to these models, we identify two main challenges for PAMC strategic planning. They stem from the uncertainty on patient's hospital choice determinants, and from the multipolar nature of the governance system, which we detail. These findings open perspectives for systems analysis and modelling in PAMC to support strategizing.

8 A modified version of this chapter is planned for submission to *Technological Forecasting & Social Change*.

1. Introduction

Confronted with the rising costs of healthcare, governments in many countries have adopted an industrial management perspective to public healthcare planning. Many techniques have been imported from the industrial setting, e.g. Lean management (Moraros et al., 2016) and strategic planning (Terzic-Supic et al., 2015). Public Academic Medical Centers (PAMCs) are a core element of healthcare systems, providing high-end care associated to clinical research and physician training. Therefore they have been fully impacted by the turn towards industrial practices (Lozeau et al., 2002).

Yet strategic planning in PAMCs produces disconcerting results (Cuccurullo and Lega, 2013; Denis et al., 1991, 1995; Lega et al., 2013). Many authors invoke the complexity of the healthcare system and hospital settings as an explanation for the limited effect of efforts to improve healthcare delivery (Georgopoulos and Matejko, 1967; Jarzabkowski and Fenton, 2006; Klein and Young, 2015; Tien and Goldschmidt-Clermont, 2009). However, the nature and sources of this complexity are often vaguely mentioned, especially in the case of strategic planning: a dense network of stakeholders, with heterogeneous values and objectives. We believe systems analysis can help to improve our understanding of why PAMC strategic planning is so challenging.

The contribution of this article is explanatory. We take the perspective of a hospital manager confronted with a strategic planning exercise. The objective is to show how different strategic planning is in PAMCs compared to the classic industrial firms for which it was developed. To this end, we develop and analyze two models: a qualitative system dynamics model of hospital operations, to analyze the uncertainty on hospital activity, and a dependency structure model of PAMC governance, to study the political network of influence. Both analysis are informed by empirical data in the French context, from case study in cancer planning at a PAMC for the system dynamics conceptual model, and from the regulation on PAMC governance for the dependency structure model.

Our analysis provides precise insights into why the results of strategic planning are disappointing in this context. It points to the uncertainty on patient choices of hospitals, which is inherent to the current healthcare system design. It also highlights the multipolar nature of PAMC governance and the position of the director at the center of a network of influence. From this analysis, we derive perspectives for PAMC planning and healthcare system reform, and opportunities for systems analysis to help in PAMC planning.

2. Literature Review

2.1. The Healthcare System and PAMCs in France

The French healthcare system is a multi-payer system. In 2014, most of healthcare fundings came from the Social Security (76.6%), the rest came from private insurances (13.5%) and patient spending (8.5%) (DREES, 2015). Hospitals moved to activity-based funding for inpatient services during the years 2000, but outpatient and ambulatory activities are funded on a fee-for-service basis (O'Reilly et al., 2012). As a consequence, the hospital's budget is directly driven by the number of patients serviced, and the system is organized as a quasi-market with hospitals (public and private) competing to attract patients (Simonet, 2014).

There are thirty public academic hospitals in France (*Centre Hospitaliers Universitaires* in French). In 2015 their global budget was around 30 billion euros, together they employed more than 378.400 people, and they were involved in 90% of medical research publications (Réseau CHU, 2016). It is difficult to estimate what share of the overall healthcare activity they perform, but regarding cancer care, they performed 21,5% of cancer surgeries, 28.5% of chemotherapy sessions and 14.2% of radiotherapy sessions in France in 2014 (INCa, 2015).

2.2. Strategic Planning in PAMCs

Operations Research/Management Science

Operations Research and Management Science have proposed a wide range of tools to support strategic decision-making in hospitals. These tools range from frameworks for planning and control (Hans et al., 2012; Vissers et al., 2001) to models for case-mix planning (Hof et al., 2015) or demand forecasting (Jalalpour et al., 2015). These models can be useful for analysts, but they have limits. First, they break down strategic planning into separate issues, e.g. case-mix planning and strategic location. Healthcare organizations have been labelled "hypercomplex" (Klein and Young, 2015). In such cases, tackling issues separately is not appropriate: one needs to anticipate the impact of one decision on other aspects. Another weakness of these approaches is that they usually take a very managerial, administrative view on the hospital. The decision-making process is assumed to be unitary, with shared goals and objectives, or if goals diverge they can be aggregated at a higher level. This is not what happens in public hospitals, where different stakeholders have contrasting, yet legitimate, demands (Jarzabkowski and Fenton, 2006). Finally, the key notion of uncertainty is not always sufficiently acknowledged. Forecasting efforts are often based on extrapolating past data, which in a turbulent environment such as healthcare is a risky path (Leggat, 2008).

Therefore such approaches give the analyst a vision of what would be an ideal decision, in a rational world. But public hospital managers cannot follow pure rationality, they have to accommodate the rationality of different stakeholders. This is evidenced by research in healthcare management.

Healthcare Management Research

Twenty years ago, Bruton et al. (1995) reviewed empirical studies on hospital strategic planning. They found few, and the literature does not seem to have grown extensively since. When we look at the citations of the early study by Denis et al. (1991), Google Scholar provides 31 results. However limited, the set of empirical studies of strategic plans by management researchers yields disconcerting results. Denis et al. (1991) carried a survey of strategic plans established by Canadian public hospitals. They conclude that these plans are "heavily oriented towards expansion, ambiguous and rather loosely integrated, leading to questions concerning their realism and utility as a basis for strategic decisions". Twenty years later, Lega et al. (2013) performed a similar analysis in three Local health Authorities in Italy. In the three cases they identified a rich set of documents, but those were loosely coordinated, with different and largely unquantified objectives, variations in language and the impression that each document is targeting a different stakeholder.

Although some studies show a positive correlation between strategic planning and hospital performance (Kaissi et al., 2008; Madorrán García and de Val Pardo, 2004), planning seems counterproductive in some instances. In a survey of strategic planning in Lebanese hospitals, Saleh et al. (2013) find no association between having a strategic plan and the occupancy rate or the revenue-per-bed. However, among hospitals with a strategic plan, their data show that hospitals with higher implementation levels have lower occupancy rates. Despite these mixed results, the design, planning and positioning schools (Mintzberg et al., 1998) are still vivid in healthcare management, with frequent calls for strategic planning (American Society of Clinical Oncology, 2009), SWOT analysis (Terzic-Supic et al., 2015; van Wijngaarden et al., 2012), scenario planning (Austin et al., 2016; Ghanem, Mohamed et al., 2015) or references to Porter's generic competitive strategies (Torgovicky et al., 2005).

But why are planning efforts so disappointing? In their study of 23 Canadian public hospitals, Denis et al. (1995) show that the highly participative strategic planning gets diluted in a political process, and that consensus is hard to reach. Cuccurullo and Lega (2013) concur in their study of two Italian PAMCs. This is for the internal complexity of public hospitals. More complexity comes from their environment (Denis et al., 1995; Klein and Young, 2015).

What remains to be defined is what the reasons for this complexity are. Many stakeholders have a say in the strategy, and the environment of public hospitals is said to be complex, which leads to a situation of "hypercomplexity" (Klein and Young, 2015). Public hospitals face both internal plurality, i.e. tensions from internal members with different objectives, and external plurality, i.e. diverging but legitimate demands from external stakeholders. They are thus defined as pluralist organizations, in which traditional strategic theory, which pictures organizations as monolithic and aligned towards shared goals, is no more adequate (Jarzabkowski and Fenton, 2006).

These are very general statements. The supposed wide number of stakeholders is not really qualified, the uncertainties on the future environment are taken for granted, and the intricate interdependency between decisions and influencers is assumed rather than proved. In one of the rare attempts to qualify this notion of complexity and uncertainty, Begun and Kaissi (2004) even conclude that although the structural complexity is high, the dynamic uncertainty is rather limited.

In this article, we propose to use systems analysis to show why the current situation (uncoordinated and largely unquantified plans, highly politicized processes) occurs, and what the perspectives for systems analysis in this context are. We start by looking at the planner's role and possibilities. We then attempt to grasp who the stakeholders in the "black box" of strategizing are and how they are linked, by modelling the political system in the hospital.

2.3. Healthcare Systems Engineering

Systems modelling has a long history of application in healthcare, with early papers in SE journals in the 1970's (Gudaitis and Brown, 1975). It is generating more and more interest following the recommendation by the US Institute of Medicine and National Academy of Engineering that more systems engineering be used to inform healthcare management and policy (Reid et al., 2005). Articles have been published in leading journals to diffuse systems methods amongst health service researchers (Pitt et al., 2016; Willis et al., 2012).

In this article, Healthcare Systems Engineering (HSE) refers to a set of SE methods for modelling, analyzing and designing elements of the global health delivery and prevention system, rather than bio-engineering or techno-biology applications. The field includes quantitative methods, e.g. for the modelling, simulation and performance evaluation of hospital departments (Fanti et al., 2013).

However, the field also requires qualitative and mixed approaches to better understand the reality of healthcare organizations, e.g. (Fradinho et al., 2014) who take a systems perspective to address operational issues in a UK and a US hospital. Indeed, like all forms of SE, HSE is in essence a pluridisciplinary approach (Tien and Goldschmidt-Clermont, 2009): health services research, industrial engineering, management research, clinical research, information systems research or sociology can all make a contribution to this emerging field. The main bound between HSE in these disciplines is the “complex view” (Morin, 1990) on reality as a set of interrelated entities, interacting along multiple dimensions.

3. Materials and Methods

3.1. Theoretical Framework: Systems Thinking and Modelling

Inside the vast domain of systemics, we work in the theoretical frame defined by French systemist Le Moigne (1977, 1990). Informed and influenced by General Systems Theory, cybernetics and Herbert Simon’s sciences of the artificial, Le Moigne describes a general system model as comprising four interdependent dimensions:

- A teleological axis: the system’s environment and its finalities;
- An ontological axis: what the system is made of, its components and the structure that binds them together;
- A genetic axis: what the system becomes, how it evolves;
- A functional axis: what the system does, how it acts on its environment.

This theoretical frame has been successfully used to study healthcare organizations, for technology integration (Jean, 2013) or risk management (Bonan-Hayat, 2007). We also build on Checkland and Scholes’ approach to human activity systems (1990), which comprises three streams of enquiry: social, a political and a logic-based. In our approach, we merge the social and political dimensions into a socio-political one that includes the dimensions of social roles and power relationships. Table 7 presents the research framework, which crosses the dimensions of Le Moigne and Checkland’s frameworks. At the intersections of the two frameworks are the models we will develop, or what needs to be explained with these models (the *explanandum*).

In our case, we want to know more about the genetic axis (the evolution of the system at the strategic level), and the emergence of finalities on the teleological axis. To do so, we propose to study the three remaining axis: ontological, functional and the environmental part of the teleological axis. We need to understand in what environment hospitals evolve, how they are structured and what they do in and to this environment. We also need to take into account both the logic-based dimension, and the socio-political one. Therefore, we propose two modelling approaches that seem appropriate for such a project: system dynamics for the logic-based dimension, and structural analysis for the political dimension. Both belong to the structuralist-functionalist paradigm, in which invisible structures bound system elements together and frame their behavior. Addressing the functional and environmental dimensions from a socio-political perspective would have required access to the strategic workshops organized in a French PAMC. This access was denied, and no readily available data (reports, publicly communicated plans, etc.) could have replaced this direct access. Without ethnographic data, we have to let these dimensions aside for now.

Table 7 - Research framework

<table>
<tr><th>Streams of enquiry
Axis
of a complex system</th><th>Socio-political</th><th>Logic-based</th></tr>
<tr><td>Ontological</td><td>Dependency Structure Modelling</td><td rowspan="3">System Dynamics</td></tr>
<tr><td>Functional</td><td rowspan="2">Not addressed in this research</td></tr>
<tr><td>Teleological—environment</td></tr>
<tr><td>Teleological—finalities</td><td colspan="2" rowspan="2">Explanandum: what needs to be explained</td></tr>
<tr><td>Genetic</td></tr>
</table>

Dependency Structure Modelling (DSM) has also been referred to as "Design Structure Matrix" (Eppinger and Browning, 2012) or structural analysis (Godet, 1986). The associated matrix models have been used in various domains, from prospective studies (Godet, 1986) to project management (Jaber et al., 2015). In DSM, interactions between entities are mapped in matrices. The matrices can then be processed, e.g. to identify clusters of entities between which interactions are denser, or to suggest better sequencing between process steps for instance.

System Dynamics (SD) (Forrester, 1961; Sterman, 2009) allows for the modelling of organizations as an interconnected system of stocks and flows, controlled by intermediate variables. System Dynamics makes a junction between the structure, the function and the environment of a system. Two key concepts in SD are the notions of feedback and retroaction. Cosenz and Noto (2016) review the use of SD for strategic management purposes. In this article, we do not develop a quantitative SD model, which would allow for simulation. We focus on a Causal Loop Diagram. This type of qualitative SD modelling is frequently use in healthcare (Kang et al., 2016; Wong et al., 2012).

Table 7 summarizes how the three models fit in a framework crossing Le Moigne's axis of a complex system and Checkland's streams of enquiries. We apply this framework to the case of French PAMCs.

3.2. Data Sources

For this study, we used two types of data sources: empirical data, mainly from interviews, and documentary sources.

The tentative instantiation of our SD model of hospital operations is based on an action-research project carried at Henri Mondor hospital. The objective was to evaluate the opportunity to invest in a new facility for outpatient chemotherapy delivery. To this end, projections of activity were necessary, which triggered the present analysis. We worked with the head of the cancer division and his administrative team, the head of the oncology department and the head of the chemotherapy unit in the pharmacy department. The project involved the use of quantitative demographic and epidemiologic data from public databases.

For the DSM model of PAMC governance, we worked from documentary sources, mainly national regulations and guidelines from national agencies. These regulations apply to all French PAMCs, therefore this method guarantees the generalizability of our conclusions.

4. Results

4.1. Challenges to Strategic Analysis—Structural-Functional and Teleological Analysis of Hospital Operations

In this section, we take the point-of-view of the analyst who wants to describe and understand what drives the evolution of a hospital. Of particular importance under activity-based funding is the level of activity of the hospital: how many patients of what type. We first propose a general system dynamics model of hospital operations, which we then instantiate for the specific case of cancer care in a French PAMC.

Generic System Dynamics Model of a General Hospital

The operations of a general hospital are represented in the SD model of Figure 27. The square boxes represent stocks, the double-arrows are flows, and the valves on the double-arrows represent the factors controlling the flow from one stock to another. The single arrows indicate influence from a factor on another one. The influential factors in the model are represented in unboxed text. The hospital is located in an area with a certain population, which evolves according to local demographics. Some of these people become "new potential patients", i.e. they require medical care. This stock of patients is distributed between the providers of the area: some go to the hospital at study, others to other providers. The ratio of patients going to one hospital over the total number of potential patients in the area is the market share of the hospital. It depends on the competition (how many hospitals, with which characteristics, are present in the area), and the attractiveness of the hospital. This attractiveness should be related to internal characteristics of the hospital: its range of procedures, its results, its pricing policy, its reputation, etc. The internal processes of the hospital are not further described in this conceptual model, but they could be modelled using DES for instance, like we did for outpatient chemotherapy delivery in Chapter III.

We identify three main uncertainties in this system:

- The local context: this includes the demographics, the epidemiology, and the local competition. These are factors in the environment, that may or may not be influenced by the hospital (for instance, demographics are almost independent), but for which precise, local information may vary greatly from more aggregated trends (e.g. at the national level).
- The interdependency between the hospital and its close environment, mainly related to patients' decisions. An organization has influence (not control) over its close environment, also called "transactional environment" (Van der Heijden, 1996: 154). There is in fact mutual influence: the organization impacts its environment (e.g. the health in the local area partly depends on the performance of the local hospital) and the environment impacts the organization (e.g. local decisions on public transportation will influence hospital accessibility). But what is the nature of this influence? What's the impact of a hospital's behavior on its local context and its capacity to acquire patients (competition and attractiveness)?

- The contextual environment: the hospital is dependent on major trends in the global environment. The dimensions of these trends are often referred to as PESTEL: Political, Economic, Social, Technological, Environmental and Legislative.

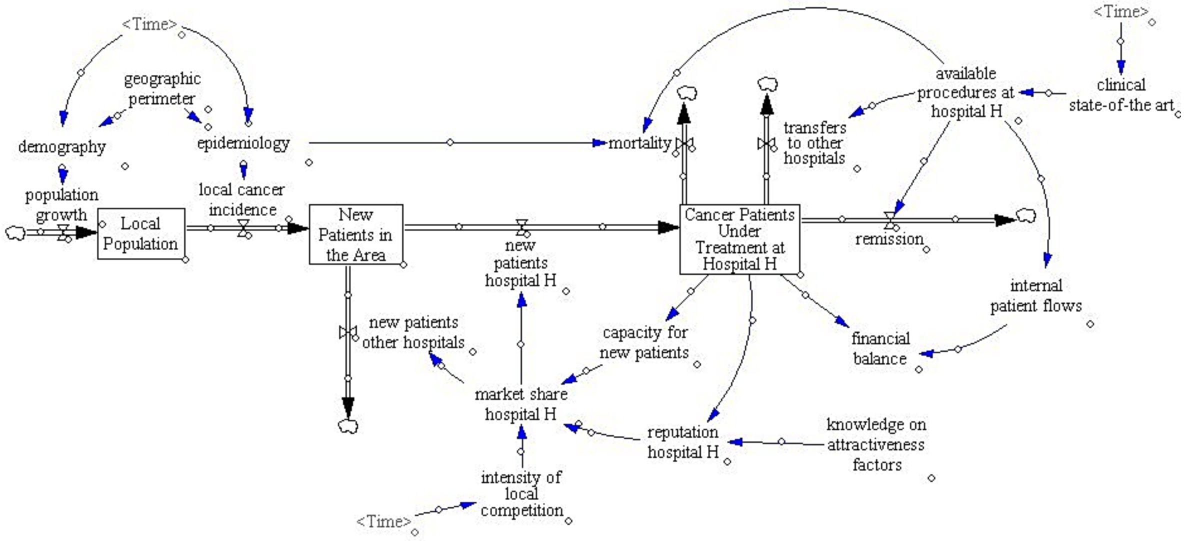


Figure 27 - SD model of a general hospital

Case Study of Cancer Care in a Paris Suburb PAMC

We now propose a case study of cancer care in a suburban area near Paris. This project started from a simple question: in the perspective of constructing a new facility in a hospital, we asked ourselves how many chemotherapy sessions we could plan to be delivering in ten years from now. To this end, we developed the model of Figure 27, and worked to feed it with data. We now describe this process of instantiating the conceptual model with real data based on Henri Mondor hospital.

We first started with the local context. Demographic projections are easy to come by, and they have proved to be relatively accurate in the past. The National Statistical Institute proposes six different scenarios for all French departments (INSEE, 2011). Regarding epidemiology, localized data is more difficult to come by in countries with no generalized cancer register. However, in order to get a very rough idea of the differences between a department and national trends, one could mix national data from the National Cancer Institute. To do so, the number of new cancer cases in France in 2012 is given by (INCa, 2015). Then one could multiply this number by the population of the area of interest at time t, divided by the national population in 2012. These figures are provided by (INSEE, 2011). To account for local disparities in cancer incidence, one could then use the indicator provided by the Institute for Public Health Surveillance (InVS, 2015). This way, one can compute cancer incidence projections that account for disparities in demographics and cancer incidence. The uncertainty on such figures will be high, but their sources could be identified, and multiple scenarios could then be computed, using Monte-Carlo simulation for instance. Figure 28 shows the results of various scenarios for the incidence of breast cancer in the area. Two variables are crossed, creating four scenarios: the demography ("central scenario" and "high population scenario") and the incidence of breast cancer (with national figures from 2008-2010 or local figures from the same period). One can notice that the projections have a spread of 10% from 2030 onwards.

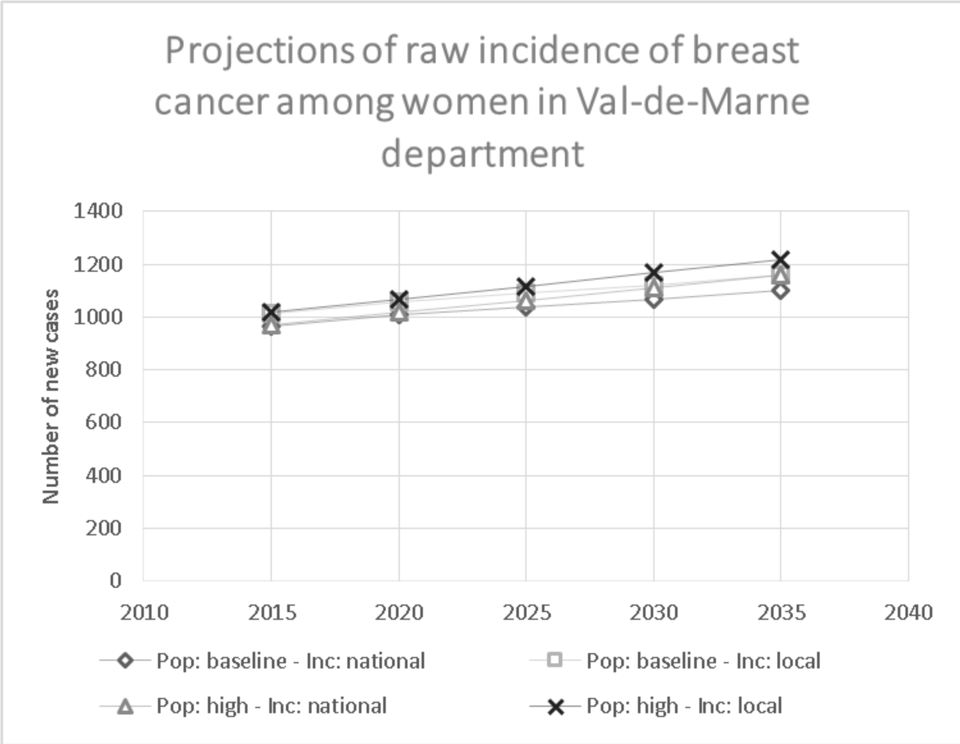


Figure 28 - Projections of raw incidence of breast cancer among women in the Val-de-Marne department (Pop: population, Inc: incidence)

Regarding "PESTEL trends", various reports from professional organizations are available which depict future scenarios, e.g. for cancer in France, some useful references are (Aitken and Kleinrock, 2016; Borras et al., 2016; Gille and Houy, 2013, 2014; Unicancer, 2013). Examples of trends derived from these reports are the development of outpatient care and homecare, the introduction of new expensive targeted therapeutics and the increased focus on integrated care.

However, when it comes to the link between the hospital's activity and its attractiveness, knowledge is much more difficult to come by. We asked managers and physicians in the hospital and could not get an answer to this simple question: how many patients can you expect next year? The analysis of the number of outpatient chemotherapy sessions in the oncology department is disconcerting: after years of steady increase (+5% to +10% per year), the number of sessions was decreasing for the past six months whereas nothing seemed to have changed in the system. After interviewing the head of the oncology department, the head of the cancer division, his administrative and nursing assistants, no explanation could be found to the recent decrease. Cancer epidemiology is on the rise, no change in personnel, procedures or waiting lists occurred during the period, and no modification to the competitive environment could be identified. So why do patients choose to come to one hospital or another?

A review of the literature shows the impact of multiple factors and diverse influences. For instance, physicians play an important role in choosing where to have major surgery: in a survey, Wilson et al.(2007) found that 42% of the patients decided equally with their physicians, and for 31% the GP was the main decision-maker. A systematic review on the choice of surgeon concludes to the "heterogeneity and complexity behind patients' reasoning" (Yahanda et al., 2016). In the case of oncology surgery, patients favor surgeons with more experience, and hospitals with better reputation and which perform the prescribed surgery more often, but they also rely on word-ofmouth and physician referral (Ejaz et al., 2014). When it comes to the wider question of choosing a physician, patients seem to be rather passive consumers of physician services (Harris, 2003).

As physicians seem to play an important role, studies have addressed their decision-making rationale. Results reported that comparative information of different providers does not influence GPs in their referrals (Ketelaar et al., 2014). A scoping review on how patients choose their providers also found that comparative information had little influence (Victoor et al., 2012).

A representation of the patient's decision situation is depicted in Figure 29. The hospital can provide some publicly available information: its prices, its location, its quality indicators and information about the physicians it employs. This information is processed by the patient's physician, based also on her past experience. The physician then issues an opinion. Similarly, the patients' relatives and a wider "general opinion" (internet reviews for instance) process the information, adding a reputation dimension to the description of all hospitals. In the end, the will try to optimize a utility function with parameters *P, T, D, Q, R* and *O*, for Price, Team, Distance, Quality, Reputation and physician Opinion.

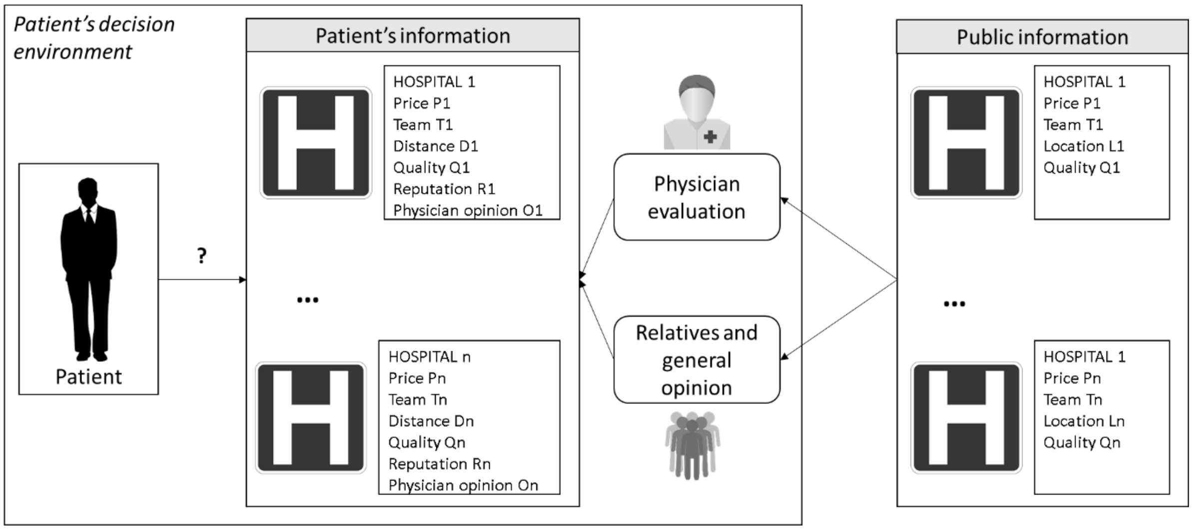


Figure 29 – Decision framework for the choice of hospital

4.2. Challenges to Strategic Synthesis—Structural Analysis of PAMC Governance

Another important aspect of complexity in PAMCs is their power structure. Hospitals are still much like the archetypal professional bureaucracy (Lega and DePietro, 2005; Mintzberg, 1979). In addition, public hospitals receive lots of pressure from public decision-makers. In France, academic hospitals include an additional layer of complexity as they share some of their employees with universities. We now describe and model this situation more precisely, to identify the network of influence in French public academic hospitals during strategic synthesis.

We identified a list of sixteen internal and external stakeholders in French public academic hospitals. The list is given in Figure 30. It includes the different status of physicians (tenured or not, professor, etc.), the governance councils (supervisory board, managing board, medical commission), the intermediate management (head of department and division), the faculty's management (dean and faculty council) and external stakeholders (ministries of health and research, regional health agency), as well as the hospital's director. This list is based on the regulations for these organizations, which have been translated into practical guidelines by national agencies (ANAP, 2010; ANESM, 2010). From these regulations it appears that the organizational structure of public academic hospitals is strongly constrained: the various boards and their composition, the nomination process for middle-managers, the internal structure (departments and divisions), and part of the recruitment process are defined. In the following analysis, we connected stakeholders in a binary square matrix *M*, with the following rules:

- If stakeholder *i* has an impact on the decisions of stakeholder *j* (e.g. can vote on her propositions or is involved in her nomination process), then $M_{ij} = 1$
- Otherwise, $M_{ij} = 0$

The result is shown in Figure 30. The original matrix, which describes qualitatively the links between actors, is provided as a supplementary file in Appendix B.

After defining *M*, we performed classical DSM computation (Eppinger and Browning, 2012): we computed matrix $M+M^2$, which we then put into binary form (i.e. all null cases remained at zero, all others were set to 1). We also set all diagonal terms to zero. This way, we can surface indirect relationships, which happen when a stakeholder *x* has influence on a stakeholder *y*, and *y* has influence on another stakeholder *z*. In this case, *x* has indirect influence on *z*. The results are shown in Figure 31. The last column sums the number of stakeholders over which stakeholder *i* has influence, we call it the influence score of *i*. The last line sums the number of stakeholder who have influence on stakeholder *j*, we call it the dependence score of *j*.

	Ministry of Research	Ministry of Health	Regional Health Agency	Hospital Director	President of the Medical Commision	Hospital's Medical Commission	Supervisory board	Managing board	Head of Division	Head of Department	Faculty Council	Dean of the Faculty	Professor - Tenured physician	Assistant Professor - Tenured Physician	Tenured Physician	Non-Tenured Physicians	**Influence**
Ministry of Research	■			●													**1**
Ministry of Health		■	●	●											●		**3**
Regional Health Agency			■	●													**1**
Hospital Director				■				●	●	●					●		**4**
President of the Medical Commision					■		●	●	●	●					●		**5**
Hospital's Medical Commission				●	●	■											**2**
Supervisory board				●			■										**1**
Managing board				●				■	●	●							**3**
Head of Division						●			■	●				●	●	●	**5**
Head of Department										■				●	●	●	**3**
Faculty Council											■	●					**1**
Dean of the Faculty								●	●			■		●	●	●	**5**
Professor - Tenured physician						●	●				●		■				**3**
Assistant Prof. - Tenured Physician						●	●				●			■			**3**
Tenured Physician						●	●				●				■		**3**
Non-Tenured Physician						●	●				●					■	**3**
Dependency	**0**	**0**	**1**	**6**	**1**	**5**	**5**	**3**	**4**	**4**	**4**	**1**	**0**	**3**	**6**	**3**	

Figure 30 - Matrix M shows which actors have influence over which others

	Ministry of Research	Ministry of Health	Regional Health Agency	Hospital Director	President of the Medical Commision	Hospital's Medical Commission	Supervisory board	Managing board	Head of Division	Head of Department	Faculty Council	Dean of the Faculty	Professor - Tenured physician	Assistant Prof. - Tenured Physician	Tenured Physician	Non-Tenured Physician	**Influence**
Ministry of Research	■			●				●	●	●					●		**5**
Ministry of Health		■	●	●		●	●	●	●	●	●				●		**9**
Regional Health Agency			■	●				●	●	●					●		**5**
Hospital Director				■		●	●	●	●	●	●			●	●	●	**9**
President of the Medical Commision				●	■	●	●	●	●	●	●			●	●	●	**10**
Hospital's Medical Commission				●	●	■	●	●	●	●					●		**7**
Supervisory board				●			■	●	●	●					●		**5**
Managing board				●		●		■	●	●				●	●	●	**7**
Head of Division				●	●	●	●		■	●	●			●	●	●	**9**
Head of Department						●	●			■	●			●	●	●	**6**
Faculty Council								●	●		■	●		●	●	●	**6**
Dean of the Faculty				●		●	●	●	●	●	●	■		●	●	●	**10**
Professor - Tenured physician				●	●	●	●				●	●	■				**6**
Assistant Prof. - Tenured Physician				●	●	●	●				●	●		■			**6**
Tenured Physician				●	●	●	●				●	●			■		**6**
Non-Tenured Physician				●	●	●	●				●	●				■	**6**
Dependency	**0**	**0**	**1**	**13**	**6**	**11**	**11**	**9**	**10**	**10**	**10**	**5**	**0**	**7**	**12**	**7**	

Figure 31 - Matrix M+M² (diagonal cases set to zero) shows which actors have length-two influence over others

One can easily notice that although the hospital director is the most influent stakeholder (second most in the direct analysis), she is also the most dependent. Although this analysis only takes into account the existence of relationships, and not their strength, it already shows how intricate the network of influence and power is in public academic hospitals. Along the hospital's director, two balancing figures are the president of the hospital's medical commission, and the dean of the faculty of medicine. Both are physicians, elected by physicians for the former, by faculty members (physicians, researchers and students) for the latter. The dean is particularly involved in nomination processes and opening academic positions. The president of the medical commission is responsible for the hospital's medical project, which is of course a major element of the strategy.

5. Discussion

The discussion is structured is three parts. In the first one, we comment on the models developed in the previous Section. We then draw practical conclusions for strategic planning in PAMCs and healthcare system structuring. In the second part, we present research perspectives for SE on strategizing in PAMCs. We then discuss the limits of this study.

5.1. Planning, Uncertainty, and Politics

Strategic Analysis—Planning Under Uncertainty

As a result of our SD analysis, the hospital manager finds herself in a situation where patients seem rather passive, and their advisors, GPs or other physicians, do not rely on comparative information to refer their patients. If quality measurements plays little role, and the price is fixed (and patients do not pay for themselves), then how can one attract patients? Patients seem to prefer hospitals not too far (Victoor et al., 2012). However, academic hospitals are located in middle-to-large cities, where various providers will usually be available, and the distance parameter will not play.

To summarize:

- Prices are fixed,
- Quality is hard to measure (Charlesworth and Cooper, 2011) and indicators have little impact on patient's choice or physician's referrals,
- Location is unlikely to play a role in densely covered areas, where several competitors will be available within sort travel distance.

Therefore differentiation by price, quality or accessibility are not options. As a result, the system is balanced by waiting queues (i.e. patients preferring hospitals where they can enter more quickly), the ill-defined "reputation" of hospitals and physicians (Drevs, 2013; Yahanda et al., 2016) and the level of clinical innovation, i.e. by some hospitals offering unique medical procedures. This is certainly possible for some patient groups but not all, and the hospital relies on the main flow to fund the innovative procedures. Moreover, innovation is highly uncertain.

In this situation, the epistemic uncertainty (how does the way my hospital works impact on affluence and referrals?) is very high and does not allow to make informed decisions. The available control variable is the allocation of resources between different service lines, but mainstream marketing options are off the table. For the majority of patients, deriving scenarios of future activity is quite hazardous. The hospital partly relies on a network of physicians who refer their patients, but these relations happen at the interpersonal level rather than between the institution and the independent physician. Therefore, the hospital depends on the ability of its own physicians to maintain a network of referring colleagues, an activity which is not valorized.

In this context, where managers can hardly plan and have little control on the product they offer, it is not surprising that strategic plans remain vague and unquantified.

Strategic Synthesis—Planning Politics

The structural analysis of PAMC governance shows a densely connected system. The system is multipolar, with three main leaders: the director, the dean and the clinical leader. In such systems, "inflationary consensus" (Denis et al., 2007) is frequent. Negotiation, coordination and mutual adjustment are likely to play a more important role than formalization, control and hierarchy. This is reinforced by the difficulty to qualify and measure many of the organization's outcomes, including quality of care. Such a system can work provided that trust exists between stakeholders. However, in France, it has been shown that labor relationships are more conflictual than in other countries, e.g. the United States or Scandinavian countries (Philippon, 2007). If relationships are tense, then one can imagine that the dense political web can result in recurrent deadlocks.

Provided the uncertainty noticed above, this political web the focus on extension rather than downsizing noticed in PAMC strategic plans is not surprising. If the future is this blurry, one may as well promise much, rather than closing down activities that may become profitable again in the future. We believe that these results can explain the lack of focus and expansive orientation of strategic plans in PAMCs. In this situation, strategy-making is likely to continue resisting formal models and remain like Mintzberg's black box (1994), i.e. a somehow mysterious process, informed by analysts but hermetic to formal planning. So what are the consequences for strategic planning in PAMCs?

The Structure and Environment of PAMCs

For different reasons, both the content and the process of strategic planning exhibit high complexity. In the current situation, approaches based on formalizing strategic planning and looking for more rationality are unlikely to result in better results. The usefulness of industrial methods based on a mechanistic planning and control perspective in such a different context is questionable: either methods or the system will need adapting. Before looking at the research perspectives to develop new methods, we investigate potential modifications to PAMC's structure and environment.

Regarding uncertainties on hospital activity, the integration of care pathways between primary care, independent physicians and hospitals, with the definition of Integrated Delivery Systems (Lega, 2007) seems to be desirable. However, it goes against the emphasis on patient choice (Dealey, 2005) at each point of her treatment, and it faces contrary winds in the medical culture and in the way markets are organized (Bevan and Janus, 2011). Another solution could be to allow more freedom to individual hospitals to manage their offer, in order to increase competition between providers. This is a tricky issue: deregulating prices is not without consequences (Charlesworth and Cooper, 2011).

On the political dimension, one possibility would be to modify the multiple lines of management in PAMCs, with more power given to one party over the others (the faculty, the administration and the physicians). However, there are many cons to this option: giving more power to the administration could deter physicians from careers in PAMCs, bending towards physicians while administrators remain accountable for the finances looks unfair, and the faculty is a research and teaching facility with less legitimacy to interfere with hospital business. The subtle balance between values is embodied in this triple structure, and modifying it would give more prevalence to one value dimension over the others.

Given these elements, it is probably preferable to maintain status quo and instead to develop dedicated frameworks, models and methods for strategic analysis and synthesis in these organizations. It is our belief that systems analysis can help to relieve managers and improve this process.

5.2. Perspectives for Systems Analysis and Modelling

Strategic Analysis—Missing Knowledge on Hospital Operations

Strategic analysis in hospitals is made difficult by the variety and lack of interoperability of information systems. However, things are evolving fast with the help of new comprehensives databases on healthcare activity. In France, studies are now working with such databases to understand the relative evolution of patient flows in the same area, which may help to evidence the dynamics of shifting patient flows (Belin et al., 2016). The logic and methods used for analyzing national pathways, e.g. (Martin Prodel et al., 2015), is a promising way forward to understand emerging local pathways, *de facto* partnerships and referral patterns. The coupling of data-analysis on these databases to derive past dynamics of patient flows, and simulation to test new scenarios, is promising. A foreseeable challenge will be the explanation of past dynamics: why did patient flows switch at a certain time? Qualitative enquiry will be necessary to propose tentative explanations, and the analysis of concurrent dynamics in other parts of the system (competitors, and up- and down-stream care process stages) will also be precious.

Although this is less a SE issue, attractiveness models for hospitals are still needed. Field research through in-depth case-studies could help understand the decision process and its logic, and complement quantitative approaches such as discrete-choice analysis.

Strategic Synthesis—Insights from Organization Theory

In PAMCs, politics are not a disturbance in an otherwise rational system: they are at the essence of PAMC governance. To improve our understanding of the political system in PAMCs, organizational theory offers several perspectives. Only then can suitable methods be proposed.

The first one is strategic analysis, as developed by Crozier and Friedberg (1977). Strategic analysis uses a canvas model to analyze the strategic objectives of various internal and external stakeholders. These objectives will shape the strategy of the organization. This framework has had some influence in HSR, e.g. (D'Amour et al., 2008).Strategic analysis has been turned into a more computational modelling approach by Godet, with his MACTOR method (Godet, 2007). MACTOR uses DSM to analyze how the different objectives of stakeholders result in coalitions of interests. Similar DSM principles have been applied for Stakeholder Value Network Analysis by Feng et al. (2012). However, these current approaches are mainly static, and do not account for the fact that the objectives of the actors may be dependent on the objectives of others and not intrinsic. To account for this problem, agent-based modelling could be a solution. It has already been used as a way to model and explore the "Garbage can" model of organizational choice (Fioretti and Lomi, 2010).

Besides more sophisticated modelling approaches, empirical knowledge on strategizing process and strategic decision-making in PAMCs, asked for since the early 1990's (Denis et al., 1991), is still needed. Systems principles can prove insightful in this effort, as a theoretical framework for qualitative empirical research. Past examples in hospitals include Paltved et al.s' (2016) use of clinical microsystems as the theoretical background for an action research project, and the System-of-Systems perspective taken by Fradinho et al. (2014) to analyze performance issues in two high-rated hospitals. Denis et al. (2007) provide other potential theoretical frames for studying strategizing in pluralistic organizations, e.g. Actor-Network Theory.

5.3. Limits of the Study

Our study focuses on French PAMCs. Although other countries share the same global healthcare system design (quasi market, activity based funding) (O'Reilly et al., 2012), the specific constraints on organizational structures may differ. This is particularly important for our analysis of PAMC governance. Studies have underlined the specificities of the French labor relationships, in particular the lack of trust between managers and employees in private companies (Philippon, 2007), which may also reflect in public organizations.

An additional limit is the sources of data for our study of strategic synthesis. We base our model on legal data, and therefore on the theoretical organizations, requires empirical material to qualify the real relationships between different stakeholders.

6. Conclusion

In this article, the issue of strategic planning in PAMCs is studied through the lens of systems thinking. The objective is explanatory: to identify sources and causes for the reported disappointing results of strategic planning in PAMCs. To do so, a conceptual system dynamics model of hospital operations is used to understand why hospital operations are considered uncertain. We conclude that the major issue is the lack of influence hospital administrators can have on patient choice of hospital. Patients are free to choose their hospital, but there is little possibility for hospitals to differentiate from the competition, as prices are fixed, quality is hard to measure, and accessibility in urban areas is not a decisive factor. We then conduct a structural analysis of the governance system of PAMCs, which shows that hospital directors are at the core of a dense influence network. From this analysis, we discuss perspectives for research and practice. In particular, the emergence of unified national information systems in healthcare should help understand patterns in patient flows.

Conclusion

In this concluding chapter, we summarize and integrate our findings (Section 1). We then discuss the results of our work from two perspectives: our contribution to theory, by answering our three research questions (Section 2), and the implications for hospital management (Section 3). We conclude in Section 4 with some comments on the limitations of our work and the perspectives it opens for future research.

1. General Discussion

In the Introduction (Section 6), we state that "our objective is to define, adapt or combine methods to generate improvement in efficiency in hospital operations. A specific emphasis is put on sources of complexity: interdepartmental coordination, and political or power relationships. Therefore, we take special interest in the coordination perspective". The following research program was divided in three phases: a structuring phase, using the VSM, followed by two projects, a process redesign project and a scenario planning project. Each of these phases generated its own learning explicated in the corresponding chapters, but we now attempt to compare and integrate these three phases.

1.1. Summary of the Results

In this thesis, we have used different research methods. Our works tackle interdepartmental coordination in hospitals, with a case study in outpatient chemotherapy. The objective in the case study was to reduce waiting times in the outpatient oncology clinic at Henri Mondor hospital.

We started with a systematic literature review on the area of our case study. This review showed that outpatient chemotherapy is a good example to study interdepartmental coordination, but that very few papers (only one is fully in line with this perspective) have taken this angle to study it. We also evidenced specific research challenges related to the modelling and optimization of outpatient chemotherapy planning.

We then developed an action-research program at Henri Mondor hospital to study in action an effort to integrate two hospital departments. The first phase was aimed at the definition of a change program, and launching this change initiative. It relied on the VSM and Kotter's 8 steps for leading change. This initial phase succeeded in generating change, as two projects were launched. The relevance of the insights generated by the VSM can be assessed by the acceptance of the projects deduced from the VSM analysis.

The first project suggested by the VSM analysis was to reinforce the coordination function between the outpatient unit where chemotherapies are administered and the pharmacy unit where they are prepared. We combined qualitative and quantitative methods, Soft and Hard OR. The main concept selected was to contact patients prior to their chemotherapy, to check on their status, and if possible to prepare their drugs in advance. The new coordination function would coordinate the pharmacy and the oncology clinic, but also support coordination with patients and external biology labs. The implementation of the solutions is still going on at the time we write this thesis, but simulation modelling and expert opinion give us confidence that the solution is viable.

The second project suggested by the VSM was the building of a development function in the system, which would carry prospective analysis and focus on stakeholder management. It was attempted in a scenario planning project, which could not go to its conclusion due to insufficient knowledge available on patients' determinants when they choose their hospital. To examine further this issue, we developed models of hospital operations and of PAMC governance. These two models helped us explain why strategic planning in hospital is so hard to implement. It led us to formulate research perspectives based on healthcare data analysis, which we intend to develop now.

After reviewing the results, we now give some elements of integration of these results.

1.2. An Integrative View on the Interventions

As represented in Figure 32, there seem to be two logics at play in the global program presented in this dissertation:

- A converging logic when a process is progressively from a broad objective defined during the structuring phase;
- A diverging phase when, starting from a situation where the future is unknown but also unthought-of, we attempt to define a set of scenarios about the future. These scenarios "open up" the vision of the future, from a "business as usual" perspective to a more diverse and inventive perception.

By "converging" and "diverging" we refer to the number of available options, which is progressively reduced in the top project and progressively increased in the bottom project.

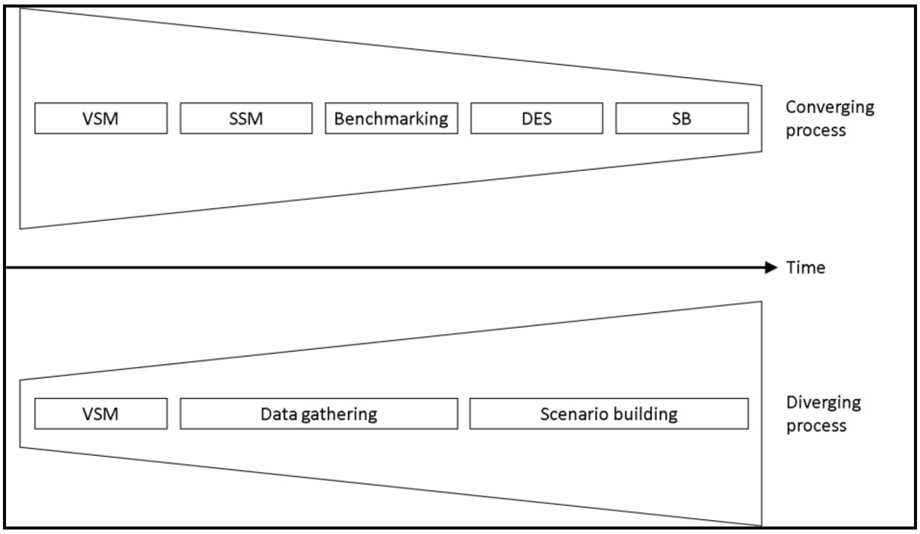


Figure 32 - Converging and diverging logics in the interventions described in this dissertation

However, we can analyze *ex-post* the logic in the two projects by integrating them in a global program. Figure 33 shows this program as it was supposed to unfold. The diverging process at play in the scenario planning project did not converge because the project did not reach its completion, but the ultimate objective was to converge towards a strategic plan and a concept for a new organization of cancer care delivery at the hospital.

This figure shows that the overall logic remains converging. It also shows how, through the generation of knowledge in the project (here, the attempted scenarios), the process can alternate between diverging and diverging phases. These two notions (alternating between convergence and divergence, in an ultimately converging process) is consistent with traditional views of the design process like the double-diamond model of design (Norman, 2013).

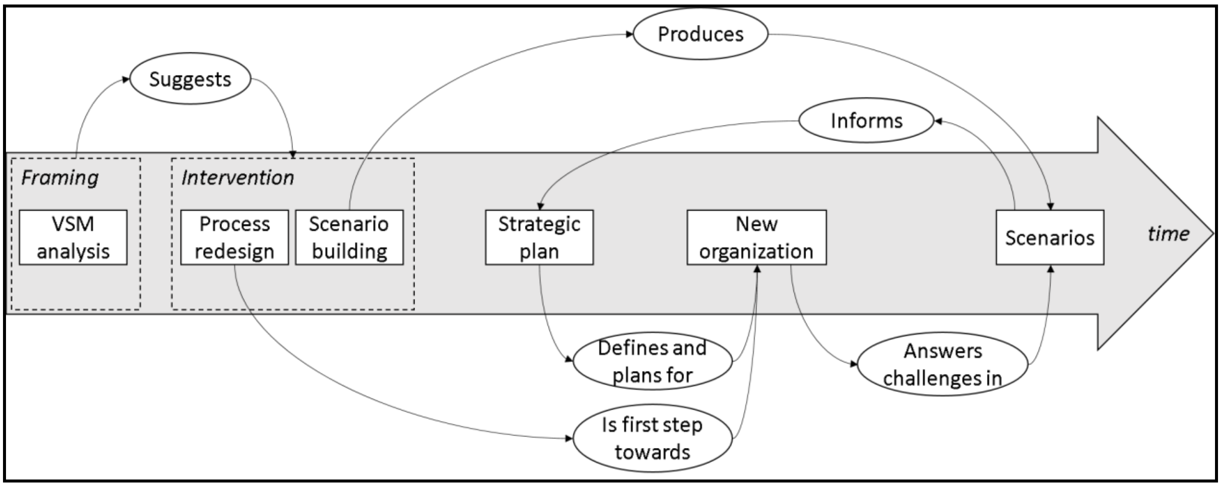


Figure 33 - Chronological view of the envisioned global program

We now turn to the reasons why we could not complete this process. One of the main differences between the process redesign project and the scenario planning project is the scope: scenario planning needs to be much more inclusive of the environment of the system.

1.3. Inside and Outside the Hospital

Our intervention led us to work at two levels:

- The hospital as a rather closed system, with well-defined boundaries, when we considered the issue of outpatient chemotherapy delivery;
- The hospital in its environment, with more permeable boundaries and much stronger interactions with external stakeholders, when we considered the long-term dynamics of hospital activity in our scenario planning project.

Inside the hospital, although coordination is an issue, it is possible to identify processes, and gather their participants in one room. Outside the hospital, the same upstream step in a care process can be performed by tens of professionals. Inside the hospital, although power is diffuse and less hierarchical than in other organizations, there is organization and structure. Outside the hospital, activity is guided by a set of rules and defined medical practices, but there is no one in charge of patients' trajectories. Inside the hospital, our intervention was successful in generating change. When we set out to analyze the connections with the greater healthcare environment, the project failed because no structure could be identified in this environment. The process structure which can be adopted as a model to

Therefore, if much remains to be done inside hospitals and more generally inside healthcare organizations, we feel that the challenge of coordination between care providers is much greater. Structuralist systems approaches may not be adequate here. Systems-of-systems, data-driven network approaches or agent-based models and a shift towards more methodological individualism than structuralism should be explored. We detail one particular perspective in Section 4.2.

2. Theoretical Contributions

After the general comments of the previous Section, we now summarize our answers to the three research questions we defined in the Introduction.

2.1. Methods for Change Management in Multidepartment Systems

Our first research question was "How should a change program in a multi-department setting be designed and managed?" It was detailed into two sub-questions: "How can one concurrently structure and trigger a change program in a multi-department setting?" and "How should one proceed to redesign processes routinely involving two or more hospital departments?" These two questions are clear problem-solving questions. We have addressed them in Chapters II and III, with a DS perspective, aimed at defining problem-solving methods. The evaluation of our proposals was made using AR.

The first proposed method combines the VSM with the 8 steps for leading change (Chapter II). Our project validated the efficacy of this method: a change program was structured, and it triggered action. The projects that followed were deemed relevant by involved actors. The method is also efficient: it took the analyst a few months to build his model of the situation thanks to the VSM and launch a change initiative following Kotter's 8 steps.

The second method is presented in Chapter III and combines SSM, DES, benchmarking and SB. The application generated collaboration and new insights into the coordination issue in outpatient chemotherapy. The method is effective: it generated awareness of the connection between two departments, and all the quickly enforceable changes which had been approved have been implemented. The method is also efficient. It balances participative workshops with more traditional OR analysis, thus it is adequate for healthcare settings, where it is hard to hold group works due to the limited time available from medical staff.

The connection of these methods is a possibility but not a necessity. The first stage, with the "VSM + 8 steps" method, could result in the definition of a process redesign project, but this will not be the case for every project.

2.2. A Solution for Outpatient Chemotherapy Planning

Our second research questions was "How can one improve outpatient chemotherapy delivery?" It was divided into two sub-questions: "What quantitative models have been developed for studying and improving outpatient chemotherapy planning, and how relevant are they compared to practice?" and "Is there a robust concept that would allow for a reduction in patient waiting times in outpatient chemotherapy?"

The first sub-questions is answered in Chapter I, with our literature review on outpatient chemotherapy planning. We identify 25 papres which together show that outpatient chemotherapy requires specific models due to the characteristics of the formal models it generates. The coupled appointments, the multidepartment aspect and the tolerances on appointment dates make it a complex and interesting issue, different from the classical appointment scheduling literature or from surgery planning. We show that one particular aspect of outpatient chemotherapy is understudied: the coupling between drug preparation in the pharmacy and drug administration in the outpatient clinic.

As our literature review focuses on quantitative models, the solution concept we finally go for in order to reduce patient waiting times is not included. This concept is to contact patients before their chemotherapy, to gather information in order to prepare their day at the hospital. Although we did not include it in our survey, this concept is not new, it was proposed by a team at Hôpital Européen Georges Pompidou (Berhoune et al., 2010, 2011; Scotté et al., 2013). We met with one of its inventors, Dr Brigitte Bonan. The contribution of our work is to confirm the robustness of this approach, using simulation. We have also gathered evidence from another hospital who use the same concept (Hôpital Cochin), with the same impact on patient's waiting times. On this point, our contribution is both replicative, and in the explanation of the advantages of this concept from an OM/OR perspective.

2.3. Explaining the Failure of Strategic Planning in PAMCs

Finally, our third and last question was "Why do strategic plans look so disconcerting and disappointing in PAMCs compared to other industrial firms, when similar methods are applied?" We address this question in Chapter IV. Our contribution is explanatory. We use systems thinking and systems modelling to identify two main factors which hinder strategic planning in PAMCs: the "market structure" in French hospital care, and the governance structure in French PAMCs. The first factor generates uncertainty and limits control over operations. The second factor leads to a dense political game, which makes it difficult to come to a consensual plan, given the diverging point of views and perspectives on value.

3. Managerial Implications

We hope to have made clear throughout this dissertation our strong commitment to advancing at the same time practice, as well as theory.

3.1. Managing Complex Organizations

The first practical conclusion of this work is a renewed call for integrative thinking in hospital operations management. This requires to reach out beyond department boundaries, which we think is not as big a problem as making time for such contacts. Operational management decisions seem to be mainly made "on the spot", as issues arise. Yet decisions on connected hospital flows require concertation and some time to discuss the stakes of each participant.

In French public hospitals, "*pôles d'activité*", i.e. multidepartment divisions, have been created to improve coordination. However, the definition of these structure is not necessarily congruent with patient flows, in our case the oncology department and the pharmacy unit are part of two separate divisions. We believe that the complexity perspective calls for new roles to be defined in hospitals, which could be coordination nurses or more managerial/administrative profiles. These professionals would be in charge of a set of care process, for which they would manage the coordination tools (meetings and other routines, information systems). The risk is that these roles and tools be transformed into bureaucratic, political objects, the same way Lozeau et al. reported it for quality management and strategic planning (2002). The introduction of such roles in the complex double management line in public hospitals must be thought carefully.

3.2. Applicability of our Methods

A point that needs to be discussed is the applicability of the methods we propose and their usability by hospital managers or clinicians. Who should use it? In which situation? We shall answer these questions for both the “VSM + 8 steps” and the process redesign method.

VSM + 8 steps

This method is for initiating a change program. It requires some leadership skills, and a good knowledge of the cybernetic principles at work in Stafford Beer’s VSM. The trickiest part is probably the identification of the system-at-study, which is both a choice and a commitment for the rest of the study. This step requires that the analyst thinks beyond organization charts and rather focuses on viability of the defined system.

An important issue here is for the change proponent to appear at the same time legitimate in his action, and not partial to one particular department, person or other. If the project is within the boundaries of one of the multidepartment divisions discussed above, then the division managers are indicated to lead the project. Otherwise, it should be the role of the “operations” departments, which are becoming more frequent in French public hospitals, e.g. Hôpitaux Universitaires Paris Sud, where a small team is dedicated to such projects.

Process Redesign Method

This method is maybe harder to master as it works between two different paradigms, and uses quantitative modelling (DES), which requires skills with a DES software. Some software has been developed specifically for the healthcare industry, but we have not tried it. The time required for this method (especially the time spent in benchmarking interviews and visits, time studies, simulation studies) makes it best indicated for dedicated staff. The technostructure is notoriously weak in hospitals, yet it is the only place where such skills can be located. The creation of small management engineering teams should be tested and evaluated.

4. Limitations and Further Research

We now discuss the limitations of this work, and the perspectives that can be drawn for future research.

4.1. Limitations

There are two kinds of limitations to this work: first, on the generalizability of the findings, and second, on the scope of the research. Regarding the generalizability of our findings, we are bound by the limitations inherent to AR. We carried projects in one specific context. This results in

> *“*substantive theory of the mid-range variety*. Substantive theory is described by Glaser and Strauss* (1967) *as a context-dependent theory that is developed for a narrowly defined context and empirical application, where the contextual boundaries of the theoretical argument are important. Many theories in OM are substantive in the sense that they are clearly more applicable in some contexts than others . . . the kind of generalizability associated with substantive theory is not of the statistical variety, rather, it is generalizability in the theoretical sense: to what theoretical discourse or research program do the results contribute?”* (Holmström et al., 2009: 75–6)

We discussed the scope of validity of our findings in each Chapter. The research programme to which we hope to contribute is that of the application of OM/OR M&S tools to the healthcare sector, which covers the exaptation of tools from other sectors, and the associated necessary knowledge of the healthcare sector. To increase the validity of our findings, replication studies would be a first stage.

A second limitation of our work is in its scope. In Chapters II and III, we worked with physicians, pharmacists, pharmacy assistants and nurses. This is already an interesting variety. Yet two major categories of stakeholders did not directly participate: the administrative staff ("*la direction*") and the patients. The administration's input is important to take into account politics from the beginning of the project. We have considered some political complexity, at the interdepartmental level, but we remained in a mainly clinical and nursing culture. We suspect that for the other participants, we ourselves, actually embodied the accountant's perspective in these projects.

Besides, the patients' input is also paramount if we are to move towards patient-centered care. Collaborative workshops with patients already exist. We did not take that path, because of the difficulty to frame projects involving patients. It was also already sufficiently difficult to manage the gap between the engineering and managerial culture we came from, and the clinical and nursing cultures.

4.2. Further Research

Given the limitations discussed above, and the findings of this work, we identify three main perspectives for future research.

Expand our Process Redesign Approach

First, we should expand our approach to take into account the perspectives of the patients, and the administration. Involving the administration is easier from the research planning perspective, as there are less ethical issues. The main challenge for the researcher in this case is to remain as neutral as possible. Perfect neutrality is impossible, but the researcher cannot be perceived to support one side more than the other. We could then move on to include patients in the projects to reach co-design (Bate and Robert, 2006; Jansen et al., 2015; Marc Steen et al., 2011; Robert et al., 2015).

Data Analysis to Understand Internal Patient Flows

Building change programs, redesigning processes and writing strategic plans: all depend on the level of activity of the hospital. However, this is still poorly understood. Where do patients come from? Why is the activity fluctuating? These questions cannot be answered with current methods. We believe that the new national databases for hospital stays can help. Some studies have already been published that use this database, *Programme de Médicalisation des Systèmes d'Information* or PMSI, to analyze care processes for evaluation purposes (Martin Prodel et al., 2015; M Prodel et al., 2015; Prodel et al., 2016), or to analyze the evolution of hospital activity (Belin et al., 2016). We would like to use this data to map care pathways inside the hospital and identify empirically, from the data, what are the main processes to be coordinated. If we extend the approach to other neighboring hospitals, we could identify existing partners for specific activities, which could lead to dedicated coordination resources for these care pathways.

Reflection on the Researcher-in-Residence Model

Although we have not mentioned it in the Section on limitations, our interventions raised questions on our position and legitimacy in the hospital. We worked with clinicians, and used methods they did not know of, to make recommendations. Without doubt, our status of engineer and the support of a renowned engineering school gave weight to our analysis. We tried to be transparent on motives and methods, but there was simply no time to present all the methods we used. In particular, the VSM and SSM were not presented. This is a pragmatic choice, but is it the right one? What if we had had the time to explain the roots of these models, and our partners had then declared that they did not agree with it? SSM is maybe less dangerous, because of its interpretive foundation. On the contrary, the VSM and Kotter's 8 steps take a clear functional stance, and can be used to serve whichever purposes.

In this situation, the shared knowledge we generated has no real status, it is not disciplinary, and it is highly contextual. In this grey area, the acceptability of assertions relies heavily on the trust between the different participants. We believe that this situation needs to be discussed from an ethical point-of-view, in order to assist OM/OR modellers in their interventions. What should be said, and what can reasonably remain tacit? What belongs to expertise, which can be assumed to be trusted by the partners, and what constitutes an individual choice? This is the questions that we feel need to be answered.

Appendix A. Details on the Simulation Model in Chapter III

In this appendix, we detail the data input and the validation process for the simulation model presented in Chapter III.

The simulation model was developed based on the conceptual model provided in Figure 21. An alternative view of this conceptual model is provided in Figure 34. Table 8 presents the distributions used for each service time. Data availability was very limited. Therefore the following procedure was used: the modeller (first author) would, based on observation, propose a distribution to the process experts (pharmacists, oncologists, nurses). This proposition would be discussed, complementary opinions could be asked for, and the experts would finally validate or correct the first proposition. Data from other hospitals was also used in these discussions.

Table 8 - Distributions for service times in the DES model

Process	Distribution	Method
Consultation with oncologist	-0.5 + 71 * BETA(1.86, 3.66)	Fitted (p = 0.201)
Set up infusion	TRIA(5,13,20)	Expert opinion
Injection duration	Discrete law reflecting empirical data	
Change products	TRIA(2,3,7)	Expert opinion
Take off the drip	TRIA(3,7,10)	Expert opinion
Drug preparation in isolator	TRIA(4,7,20)	Expert opinion
Prescription validation	TRIA(0.5,1,2)	Expert opinion
Kitting	TRIA(1,2,4)	Expert opinion
Transport to test and pack	TRIA(1.5,2.5,3.5)	Expert opinion
Test the preparation	TRIA(0.5,1,5)	Expert opinion
Transport frequency (AM)	TRIA(20,55,100)	Expert opinion
Transport frequency (PM)	CONSTANT(30’)	Expert opinion
Transport duration	CONSTANT(15’)	Expert opinion

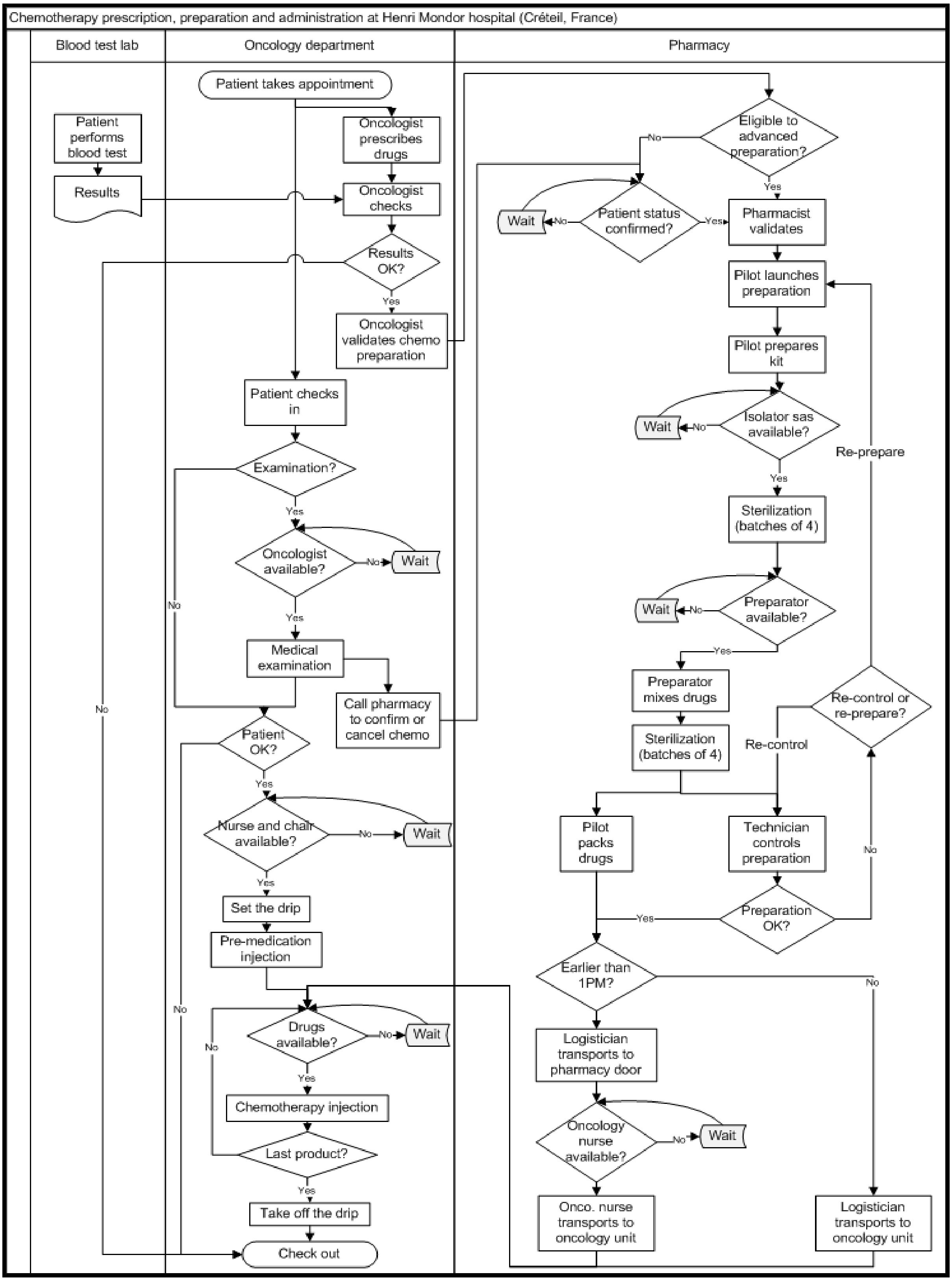


Figure 34 - Conceptual model of outpatient chemotherapy delivery process, used for developing the DES model

For validation, instructions from Robinson (Robinson, 2014) and Sargent (Sargent, 2013) were followed. Face validity was obtained by presenting the model to process experts, using animation during a structured walkthrough. Figure 35 shows results on entity validity: the distribution of the number of patients per day is very close to empirical data. As empirical data follows a normal distribution ($p < 0.01$), confidence intervals can be computed. The results are *[20.78 , 21.27]* for simulated data and *[20.13 , 22.07]* for empirical data, which validates that aspect of the model.

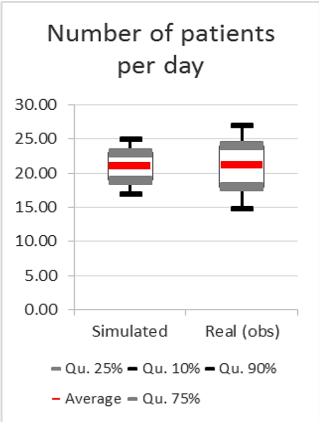


Figure 35 - Number of patients per day (simulated and empirical)

Black box validation was performed using expert opinion and comparison to historical data. Two indicators are of interest: waiting time in treatment room, and total time in treatment room. Results are presented to process experts, who approve that they are not unlikely. Figure 34 shows cumulative distributions for these two indicators. Figures 36a and 36b show that cumulative distributions for simulated data are close to empirical data. Figure 36a shows that the simulation has more patients with short waiting times than the empirical data. This can be due to empirical data, which was collected for 164 patients (59 patients on one week in March 2015, 105 patients over seven different days from June to August 2015). During the observation days, a lot of failures in pharmacy equipment happened, and one observation day took place on a week with a holiday. Therefore it may be that our empirical data does not reflect the real average situation and is showing a worse picture than what really happens. Considering that our objective is to understand the system and its behavior, we do not wish for as high level of precision as if we were fine-tuning the process. Consequently, these results are considered satisfying enough to validate the model.

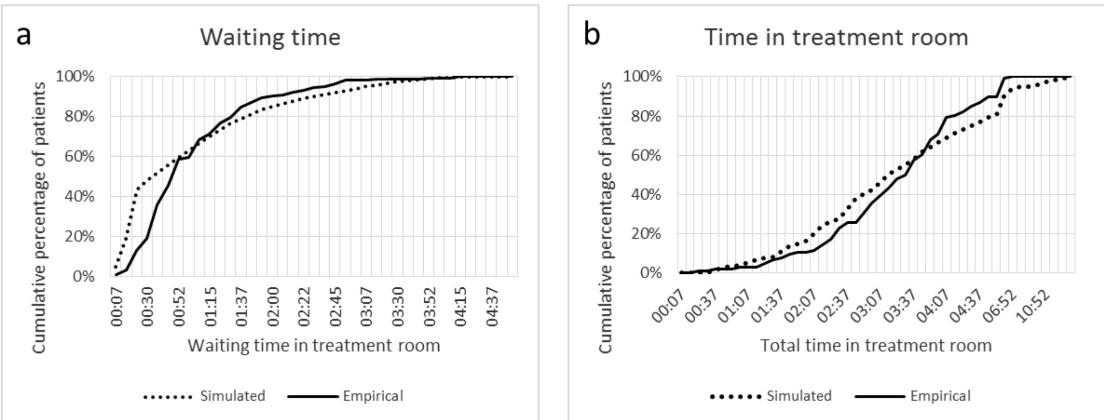


Figure 36 - Cumulative distributions for waiting time (a) and time in treatment room (b)

Appendix B. Details on the Structural Analysis in Chapter IV

In this Appendix, we provide the source elements for the structural analysis in Chapter IV. Figure 37 show the initial DSM matrix with a qualification of the relationships between actors. As such data is hard to represent on text, Excel files are available on request to the author.

a Actor in line i "has influence over" actor in column j	Ministry of Research	Ministry of Health	Regional Health Agency	Hospital Director	President of the Medical Commision	Hospital's Medical Commission	Supervisory board
Ministry of Research				nominates			
Ministry of Health			supervises	nominates			
Regional Health Agency				audits the decisions			
Hospital Director						consults	
President of the Medical Commision							participates; proposes candidates
Hospital's Medical Commission				is consulted	elects among its members		
Supervisory board				evaluates / audits			
Managing board				advises			
Head of Division						is a member	
Head of Department							
Faculty Council							
Dean of the Faculty							
Professor - Tenured physician						vote for representatives	vote for representatives
Assistant Prof. - Tenured Physician						vote for representatives	vote for representatives
Tenured Physician						vote for representatives	vote for representatives
Non-Tenured Physician						vote for representatives	vote for representatives

b

Actor in line i "has influence over" actor in column j	Managing board	Head of Division	Head of Department	Faculty Council	Dean of the Faculty
Ministry of Research					
Ministry of Health					
Regional Health Agency					
Hospital Director	nominates a part of	nominates	nominates		
President of the Medical Commision	participates; proposes candidates	proposes candidates	proposes candidates		
Hospital's Medical Commission					
Supervisory board					
Managing board		allocates resources	allocates resources		
Head of Division			monitors decisions; advises on nominations		
Head of Department					
Faculty Council					elects among its members
Dean of the Faculty	is a member	proposes candidates			
Professor - Tenured physician				vote for representatives	
Assistant Prof. - Tenured Physician				vote for representatives	
Tenured Physician				vote for representatives	
Non-Tenured Physician					

c Actor in line i "has influence over" actor in column j	Professor - Tenured physician	Assistant Prof. - Tenured Physician	Tenured Physician	Non-Tenured Physician
Ministry of Research				
Ministry of Health			nominations	
Regional Health Agency				
Hospital Director			proposes nominations to ministry agency	
President of the Medical Commision			is consulted before nominations	
Hospital's Medical Commission				
Supervisory board				
Managing board				
Head of Division	asks for new positions to be opened	asks for new positions to be opened	asks for new positions to be opened	
Head of Department	manages; asks for new positions to be opened	manages; asks for new positions to be opened	manages; asks for new positions to be opened	
Faculty Council				
Dean of the Faculty	allocates new positions	allocates new positions		
Professor - Tenured physician				
Assistant Prof. - Tenured Physician				
Tenured Physician				
Non-Tenured Physician				

Figures 37a, 37b and 37c - Sources for the binary DSM analysis in Chapter IV

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Personal Publications

For an up-to-date list of the author's publications: https://cv.archives-ouvertes.fr/guillaume-lame.

Articles Related to this Dissertation

Journals

Lamé G, Jouini O and Stal-Le Cardinal J (2016) Outpatient chemotherapy planning: A literature review with insights from a case study. *IIE Transactions on Healthcare Systems Engineering* 6(3): 127–139.

Lamé G, Jouini O, Stal-Le Cardinal J, Carvalho M, Tournigand C and Wolkenstein P (**submitted**) Interdepartmental Coordination to Improve Patient Flows in Hospitals. *Submitted to Journal of Operations Management.*

Lamé G, Jouini O, Stal-Le Cardinal J, Carvalho M, Tournigand C and Wolkenstein P (**submitted**) Multidepartment integration: a multimethodology to initiate a change program in a hospital's cancer division. *Submitted to European Journal of Operational Research.*

International Conference Proceedings

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Lamé G, Yannou B and Cluzel F (**submitted, minor revision**) Usage-Driven Problem Design for Radical Innovation in Healthcare. *Under minor revision for BMJ Innovations.*

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université PARIS-SACLAY | ÉCOLE DOCTORALE INTERFACES Approches Interdisciplinaires : Fondements, Applications et Innovation

Titre : Intégration entre services hospitaliers : management des opérations en cancérologie

Mots clés : Gestion des opérations, Gestion hospitalière, Ingénierie des systèmes de santé, Chimiothérapie, Coordination, Gestion des flux de patients

Résumé : Ces travaux s'intéressent à la coordination entre services au sein d'un hôpital. Il s'agit d'améliorer la prise en charge des patients en prenant une vision de leur parcours qui intègre toutes les unités impliquées. Nous nous sommes particulièrement intéressés au cas de la chimiothérapie ambulatoire, en partenariat avec l'hôpital Henri Mondor de Créteil. Trois questions sont traitées :

1. Comment concevoir et mener un programme de changement dans un contexte multi-services à l'hôpital ?
2. Comment améliorer la délivrance des chimiothérapies ambulatoires ?
3. Pourquoi la planification stratégique dans les Centre Hospitalo-Universitaires donne-t-elle des résultats décevants, comparés aux contextes industriels où ces approches ont été appliquées avec succès ?

Pour répondre, notre principale méthode d'investigation a été la recherche-action. Dans le cadre de projets de réorganisation à l'hôpital Henri Mondor, nous avons adapté et combiné des méthodes de recherche opérationnelle et de génie industriel pour prendre en compte les spécificités du contexte hospitalier. Nos travaux aboutissent à la proposition et à l'évaluation de méthodes de réorganisation centrées sur la coordination entre services, et sur une meilleure connaissance de l'environnement spécifique de l'hôpital, un contexte différent de ceux où s'est traditionnellement développé le génie industriel.

Title : Integrating hospital departments: an operations management approach for cancer care

Keywords : Operations management, Hospital management, Healthcare systems engineering, Chemotherapy, Coordination, Patient flow management

Abstract: This dissertation addresses the challenge of coordinating hospital services. We take an integrated view on care delivery and the various units involved in a care process, with a case study in outpatient chemotherapy process at Henri Mondor hospital, Créteil, France. We tackle three research questions :

1. How should a change program in a multi-department setting be designed and managed?
2. How can one improve outpatient chemotherapy delivery?
3. Why do strategic plans look so disconcerting and disappointing in public academic medical centers, compared to other industrial organizations, when similar methods are applied?

Our main research method is action-research. During reorganization projects, we adapt and combine methods from operational research and industrial engineering in order to integrate hospitals' specificities. We propose and evaluate reorganisation methods focused on interdepartmental coordination, and we contribute to a better knowledge of the specific environment of hospitals, which is quite different from the contexts in which industrial engineering traditionally developed.

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