EGOS 2013 - Sub-theme 27

Breaching and Bridging Boundaries:
Towards a Deeper Understanding of Transboundary Crises and Risks

Managing risks across organizational actors boundaries: the case of the medical nuclear supply chain

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INTRODUCTION[1]

For several years, nuclear medicine has faced a growing development due to medical innovations in this area (production of new radiopharmaceuticals, positron emission tomography). Radioisotopes used in medicine are specifically produced to emit gamma rays of sufficient energy so they can be detected by a sensor equipment that produces an image (Ponsard, 2010). Today, half of the people are estimated to potentially benefit from nuclear medicine in their lifetime, either in a diagnosis perspective or in a therapeutic perspective (World Nuclear Association, 2009). Paradoxically, nuclear medicine is less brought in public and political debate than nuclear energy.

Nuclear medicine covers some very important issues for patients, for medical practice, and for radiopharmaceutical production and logistics. These issues may be taken into account in the perspective of diverse disciplines, and in particular in the management field. Given radiopharmaceutical specificities, and especially their short lifecycle (from a few hours to a few days), the value of the radioactive elements decays very quickly, and logistics becomes a key factor in the performance of nuclear medicine (Nagurney and Nagurney, 2012). As such, a just-in-time logistics scheme has to be implemented from production to use, and is subject to very high stresses. In the context of nuclear medicine, one of the main objectives is to avoid any crisis in production, transportation, use and recycling, for obvious safety and security considerations (OECD, 2010). This question has been considered for a long time in terms of organizational optimizing (Emmons, 1968) but much less in terms of inter-organizational risks.

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Crises disrupt existing organizations by bringing dilemmas in decision making (Aguilera, 1990). The literature has defined three major phases in crisis management, dealing with threats before, during, and after they have occurred (Barton, 1993). The first phase is about risk anticipation and risk prevention. In the second phase, the crisis has triggered, and organizations have to manage the crisis. The last phase is a post crisis phase, which objective is to improve organization's ability to anticipate or respond to other future events. In this research, we are particularly interested in the first phase since we focus on risk management in the medical nuclear supply chain. Risk management involves assessing potential threats and organizing in order to avoid those threats.

Following Mentzer et al. (2001), we define supply chain as "*a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer*". Given the implication of several entities, the importance of coordination has been underlined among the diverse practices for managing supply chains facing crisis (see Natarajarathinam et al., 2009 for a review). Past literature has not paid enough attention to risk management in the nuclear medicine supply chain, and especially on how actors of the nuclear medicine supply chain manage and share risks. This paper aims to advance knowledge of how organizational actors experience and understand transboundary organizational risks. Our research question is: how the actors of the medical nuclear supply chain collectively coordinate for managing risks? To do so, we take acknowledge the multiple views of risks (Gephart et al., 2009) and focus on the specific context of supply chain.

The rest of the paper is organized as follows. First, we define the key concepts of the research by identifying the main actors of the medical nuclear supply chain and we review how the literature deals with risks in the context of supply chain. Second, we present the ongoing case study and the present findings focused on the challenges existing at the interfaces of the multiple actors and the boundary difficulties along the supply chain. Finally, we discuss the results and the role of information exchanges for supply chain actors to overcome information and knowledge boundaries.

1. CONCEPTUAL FRAMEWORK

1.1. Initial view on the medical nuclear supply chain

The supply chain network for nuclear medicine can be described as quite complex, involving multiple actors and activities, from production and transportation to processing (Nagurney and Nagurney, 2012). This network has to collectively manage the constraints of radioisotopes decay. The hazardous nature of the product also implies restrictions to transportation.

Following Ponsard (2010), we can describe the technical process of the medical nuclear supply chain as follows: The steps of the chain start with the nuclear reactor (fission step), then the processors ("bulk" radioisotopes processing), followed by the generators manufacturing facilities (manufacture of ready-to-administer radiopharmaceuticals) and, finally, the healthcare facilities (hospitals or central pharmacies) where the nuclear medicine is used for medical treatments. Ponsard (2010) describes the multiples steps to manufacture the Mo-99/Tc-99m radioisotope, which is the most commonly used medical radioisotope (figure 1).

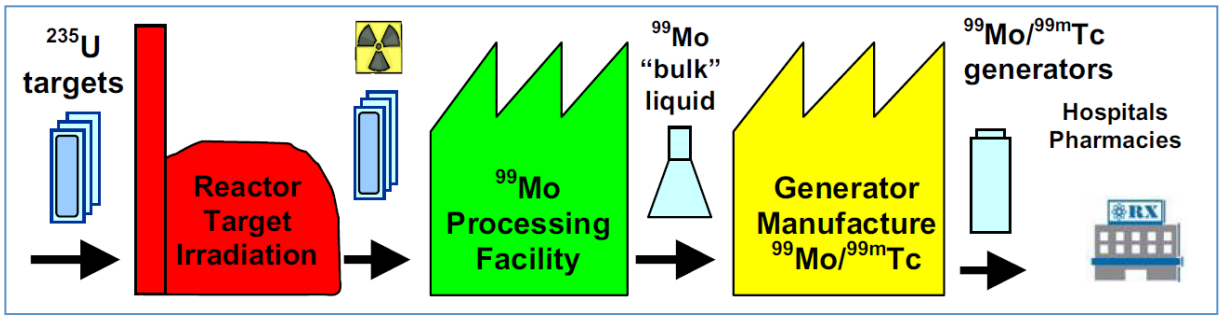


Figure 1 – Mo-99 Radiopharmaceuticals manufacturing process of: the case of Mo-99/Tc99m (Ponsard, 2010).

In the case of Mo-99/Tc-99m, the radioisotope looses 1% of activity per hour so it can be used for only one week, and the all process highly time-sensitive. As indicated by Ponsard (2010), "*each partner in the supply chain must thus work very efficiently to avoid losing time so that the product can be delivered as quickly as possible, taking shipment constraints into account*." Moreover, the M-99 radioisotope is extremely

radioactive, so the transportation options in the first steps of the process are significantly constrained (trucks and containers). When the decay of the radioisotope is more advanced, other transportation options can be considered (air, etc.). This double constraint explains why the actors of the supply chain are labeled as ‘partners’ (Ponsard, 2010) or ‘stakeholders’ (OECD, 2010).

Each radiopharmaceutical has its specificities in terms of level of radioactivity, time-sensitivity, and manufacturing chain (for example, M-99/Tc99m is highly centralized in the first steps of production). Before studying any specific case, we aim to understand the general challenge of inter-organizational risks along the nuclear medical supply chain.

1.2. Characterization of risks in supply chain

In supply chains, risk management is defined as "*the process whereby decisions are made to accept a known or assessed risk and/or the implementation of actions to reduce the consequences or probability of occurrence*" (Kumar, 2009). In fact, risks are associated to potential events that should have a negative impact on the overall performance of the supply chain (Christopher and Lee, 2004). Supply Chains risk is specific because it is bore not only by a single organization but also by organizations together. Indeed Supply Chain risk can be specified when at least three organization are involved. In the Supply Chain context the risk can be defined as the probability and the consequence of an incompatibility between supply and demand (Jüttner, 2002). During the recent decades, supply chain research and practice have integrated risk considerations as part of the supply chain management. Several tools or practices have emerged, such as Supply Chain Risk Management (SCRM), which is defined as ‘‘the management of supply chain risk through coordination or collaboration among the supply chain partners so as to ensure profitability and continuity’’ (Tang, 2006). Nevertheless it is important to keep in mind that SCRM do not only aimed to avoid the risk but may also lead to mitigate, transfer or share the risk. Risk Management may become even more complex by interrelated events and activities: reducing one risk can lead to intensify another (Chopra & Sodhi, 2004).

For integrating those risks as part of the supply chain management for improving the resilience of the supply chain (Christopher and Peck, 2004), the nature of the risks have to be defined and analyzed. Manuj and Mentzer (2008) have proposed eight types of risks that are likely to trigger crisis within a supply chain: Supply Risks, Operational Risks, Demand Risks, Security Risks, Macro Risks, Policy Risks, Competitive Risks, Resource Risks. Their antecedents are presented in Table 1.

Type of risk	**Source**
Supply Risks	Disruption of supply, inventory, schedules, and technology access; price escalation; quality issues; technology uncertainty; product complexity; frequency of material design changes
Operational Risks	Breakdown of operations; inadequate manufacturing or processing capability; high levels of process variations; changes in technology; changes in operating exposure
Demand Risks	New product introductions; variations in demand (fads, seasonality, and new product introductions by competitors); chaos in the system (the Bullwhip Effect on demand distortion and amplification)
Security Risks	Information systems security; infrastructure security; freight breaches from terrorism, vandalism, crime, and sabotage
Macro Risks	Economic shifts in wage rates, interest rates, exchange rates, and prices
Policy Risks	Actions of national governments like quota restrictions or sanctions
Competitive Risks	Lack of history about competitor activities and moves
Resource Risks	Unanticipated resource requirements

Table 1 – Type of risk and sources in supply chains (Manuj and Mentzer, 2008)

In the nuclear medicine supply chain, several types of risks may be taken into account. Because of the nature of the resource, which are radioactive elements, risks related to safety and security are of critical importance (OECD, 2010). Because of the

short lifecycle of nuclear medicine, risks related to procurement need to be managed by the implementation of a just-in-time (JIT) Supply Chain (Nagurney and Nagurney, 2012). The JIT Supply Chain involves to synchronize the flows: information, material, product and patient, in order to manage the risk and to reduce the costs. It is important in such a field to distinguish the “classic” logistics and the “service” logistics. In fact the logistics in the medical organizations is still mainly seen as a “classic” logistics. This means that the logistics actors are in charge to provide all the material needed (medication, linen, catering…) for the service production. In order to accomplish their mission, the logistics actors do manage the physical flow of goods but tend to exclude from their scope the flow of patients (Sampieri-Tessier, 2002). The “service” logistics in the medical field is focused on the service production for the patient. In this case the logistics actors’ tasks are about dealing with the patient wait time and optimizing the capacities (radioactive elements, staff, scanners…) simultaneously. In this latest logistics approach, the SCRM should manage the risks from each one of the flows but has in its scope the risks emerging from the incompatibility between the material capacities and the patient needs. Following Tang’s (2006) definition of SCRM, in addition to clarify to the scope of the risk issues, we also need to understand how actors coordinate for managing these risks in the medical nuclear supply chain.

1.3. Managing risks at boundaries between the nuclear actors

Coordination mechanisms are primarily information-processing activities (Crowston, 1997). In the supply chain literature, inefficiencies are mainly linked to asymmetric information or distorted information (Lee et al., 1997). Information can be used as a tool for improving supply chain efficiency and coordinating inter-organizational activities (Tan, 2001). In a supply chain analysis, it is valuable to consider information exchanges between supply chain partners for analyzing coordination. To describe and understand how actors coordinate (or not) with each other for managing risks in the medical nuclear supply chain, we rely on coordination theory. Malone and Crowston (1994) define coordination as the management of dependencies between activities. Moreover, Malone et al. (1999) propose three universal types of dependencies: 1) flow dependency, when one activity produces a resource that is

used by another activity; 2) sharing dependency, when several activities use the same resource; and 3) fit dependency, when several activities produce a single resource.

The multiple existing dependencies can be interpreted in terms of knowledge that needs to be shared. As Carlile (2004, p.559) underlined: "*[...] when actors have different interests, the dependencies between them are not indifferent [...]. Under these circumstances domain-specific knowledge, as well as the common knowledge used, may need to be transformed to effectively share and assess knowledge at the boundary*". The dependencies existing at the boundaries along the supply chain constitute a manner to assess risk management.

For a theoretical understanding of risk management in the medical nuclear supply chain, we consider managing risk as a boundary crossing activity, and information as a resource. For analyzing risk management in the medical nuclear supply chain, we thus need to describe: 1- boundaries between supply chain actors at which risks are managed, 2- the types of risk that are managed, 3- information and knowledge that are exchanged; 4- and how information and knowledge are exchanged by the use of the three types of dependencies.

2. ONGOING CASE STUDY

2.1. Research method and case description

L'étude empirique porte sur l'analyse de la chaine logistique des radiopharmaceutiques. Cette dernière est spécifique au type de radiopharmaceutiques préparés et administrés dans les services de médecine nucléaire. On distingue deux types de radiopharmaceutiques :

- ceux préparés in situ (c'est-à-dire dans le service de médecine nucléaire et plus précisément dans le laboratoire chaud) soit 80% à 90% des radiopharmaceutiques utilisés.
- Ceux reçus directement des cyclotron et prêts à l'emploi

L'usage d'un radiopharmaceutique (technétium 99m, Fluor 18, Iode 131, Xénon 133, thallium 201) dépend de deux variables :

- l'objectif c'est-à-dire diagnostique ou thérapeutique
- le domaine médical : neurologie, cardiologie, pneumologie, orthopédie, urologie …

Au regard de notre problématique, nous avons privilégié une méthodologie qualitative qui selon Hlady-Rispal (2002) permet d'explorer un phénomène en profondeur, à en comprendre les interactions et le rôle du contexte sur son fonctionnement. Néanmoins notre approche reste avant tout exploratoire (Hlady-Rispal, 2002) dans le sens qu'elle a pour objectif d'identifier les risques inter et intra organisationnels qui émergent à l'interface des acteurs de la chaine en s'attachant à découvrir la singularité du contexte étudié. En effet, il s'agit d'examiner un champs peu exploré dans lequel le contexte est déterminant pour l'élaboration du processus de compréhension de la situation observée (Evrad et al., 2003).

Le terrain analysé concerne le service de médecine nucléaire d'un centre hospitalier universitaire de la région ouest de la France. Concernant la chaine logistique des radiopharmaceutiques, le service de médecine nucléaire occupe une place centrale. En effet, c'est la programmation des examens qui déclenche le processus de commande des radiopharmaceutiques suivant une logique de flux tirés. A partir de ce service, on peut ainsi appréhender la gestion des flux amont et aval de la chaine et l'émergence des risques aux interfaces des différentes activités.

Une première campagne d'entretiens réalisés sur la base d'un guide d'entretien semi-structuré a été menée auprès de différents acteurs de la chaine en lien avec le service de médecine nucléaire étudié. Ils ont été intégralement retranscrits. Le contenu des entretiens portent sur le parcours de la personne, leur rôle et place dans l'activité de logistique, les caractéristiques de leur environnement de travail et leurs pratiques de travail. Concernant le traitement des données recueillies, nous avons réalisé une analyse thématique de contenu visant à reconstruire les différents flux et les interactions entre les acteurs ((Miles et Huberman, 2003).

ORGANIZATION	INTERVIEWED FUNCTION
University Hospital Center	Head of Nuclear Medicine
	Radiopharmacist

	Laboratory technicians
	Radiology technicians
	Medical secretaries
Cyclotron	Head of Radiation protection
	CEO
	Radiopharmacist (research)
	Radiopharmacist (industry)

Table 2: list of interviewees.

Dans le cas du centre hospitalier étudié, nous nous focalisons sur un des trois services de médecine nucléaire qui y sont intégrés, celui rhumatologie, l'orthopédie, l'urologie. Un autre service est spécialisé sur des examens à visée diagnostique concernant la pneumologie, la neurologie et la cardiologie. Le dernier est spécialisé sur la médecine nucléaire à visée thérapeutique. L'essentiel des examens dans le service étudié consiste à réaliser des scintigraphies notamment osseuses. Une scintigraphie constitue un examen qui vise à explorer à partir de l'imagerie différents organes grâce à l'administration préalable dans l'organisme d'un radiopharmaceutique, issu de l'ajout d'un traceur au radionucléide. Le service travaille à 95% avec le technétium 99m, radionucléide le plus utilisés aujourd'hui en médecine nucléaire. Le service réalise 20 examens en moyenne par jour.

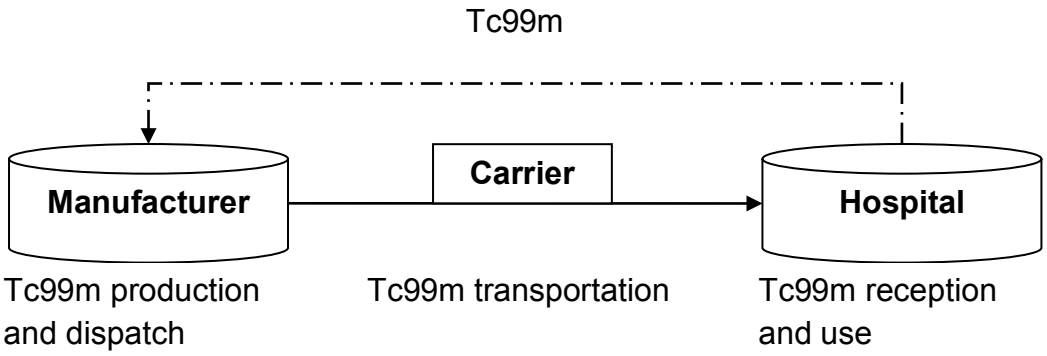
2.2. Flows description

Radiopharmaceutical logistics is built around two main flows and their pairing: radio-pharmaceutical flow and patient flow. These two flow types bring into play different actors who take action at various times of the logistics chain. We focus on one product related to one examination: the technicium-99m radionuclide used for bones scan.

2.2.1. The external supply chain: upstream flow of radionuclides

Ponsard's pattern shows us the upstream logistics, between the radionuclide production and its delivery to the Hospital.

The external supply chain :



Technetium-99m orders are scheduled on a quarterly basis by the laboratory technicians. In fact, Technetium orders are intended to predictable medical examinations for which the demand is frequent and steady. Examination cancellations, when they happen, are made up for emergency demands. " The scheduled orders are placed to the supplier because we know we will have patients for them, all the time, continuously, in the service…". "Even if there are appointment cancellations, we feel sure that we will have enough patient to make it profitable". This is not the case for all the radionuclides. Some are dedicated to less frequent examinations so they order them one by one. "As I told you, ordering is not computerized. The secretaries make the appointments, they know. A big job is made upstream: such appointment needs such order. So they write to me on a sheet of paper 'product to order'. I receive the paper and when I have it, I have a folder there and regarding the type of examination, I choose where to classify it". Every Friday, the laboratory technician asks the secretaries to edit a list in which they can read all the products to order. Then she checks out the order confirmations to ensure of the good pairing between patient appointments and products orders. Technetium-99m supplying only relies on a single supplier. The transportation is done by road and the delivery takes place twice a week: on Monday and Wednesday. This means that two generators (package which contains the radionuclide) a week match with the radioactivity needed for the weekly scheduled examinations. These generators allow to meet also the urgent bone scan demands. « We use them all the time. As soon as

we are on the next Monday, we throw away the generator received the previous week because the nuclide parent molybdenum is no more powerful enough to supply us the radioactivity needed. We then use a new one and so on ».

2.2.2. The internal supply chain: actors and activities

We now suggest to give details about the hospital internal logistics flow and then come back on the risk topic. The issue of this service logistics is to supply the right product at the right examination time to guarantee the scheduled examinations feasibility. The actors should not overestimate the number of examinations to be done. Overestimation will be contradictory with the rules regulating the nuclear medicine logistics chain:

- The ALARA (As Low As Reasoneable) principle, which involves to get the lowest radioactivity radiation as possible.
- The principle of controlling the cost, in particular those issued from the stock. The radionuclides specific features and their half-life involves that the value of these products rapidly decrease. “The technetium-99m has a lifetime of 6 hours, the parent which is the molybdenum has a 66 hours lifetime, therefore, every three days it decreases by two, this means that we cannot use it in a short while, regarding our needs”.

The internal Supply Chain management starts when the examination prescription is issued by an hospital doctor or other. The patient then makes an appointment to the secretaries. The secretaries schedule the appointment according to two elements :

- The radiopharmaceutical lead-time supply, meaning an appointment is given within two or three week-time. « The secretaries give the appointments all day long, so if I make my product orders for the two weeks coming, if they give an appointment within these two weeks, I have to re-order immediately if I don’t want to be untimely ».
- The type of examinations. They are weekdays dedicated to a certain type of examination. « We order the iodine 123 according to the number of patients scheduled and we choose a particular day to make this type of examination »

The secretaries schedule the examinations regarding the material constraints (examinations type and number) and medical prescriptions. Giving an appointment to a patient triggers the management of the two logistics flow (patient and product). The issue is to ensure on one side, that the patient will attend his appointment, and on the other side, that what should be given to the patient and what is given to the patient eventually match. On the examination day, the secretaries register the patient arrival and this information is transmitted to the laboratory technician and radiology technicians in real time. This is the patient's registration, which triggers the radiopharmaceutical preparation.

The laboratory technician prepares the radiopharmaceutical following the radio pharmacist's protocol. Preparations are made in a lead cabinet. The laboratory technician takes off the element according to the prescription, and then transfers it on a vehicle. As soon as she takes an isotope with a syringe, the calibrator measures the radioactivity taken from and indicates what is left. This is showed on GERA which is the software tracing the product radioactivity. Then the syringe is given to the radiology technicians who inject the patient. For the bones scan made with Technetium-99m, examinations are done three hours later. « In fact, our bone scans process consists in injecting the product at a T0 time and uses the medical imaging at T+3 hours, therefore the medical imaging is mostly used in the afternoons ».

Once the patient is admitted, he goes in a waiting room before a nuclear medicine doctor receives the patient for a medical consultation. This consultation aims to be sure that the medical act is justified and compatible with the patient medical condition. The doctor also informs the patient about the examination and the necessary measures he has to take. Following this consultation, the patient goes to be injected. For the bone scans that are the majority of the service examinations, the patient leaves the hospital after the injection, unless he's hospitalized. He comes back afterward for the medical imaging three hours later and goes home when it is over. In accordance to the ALARA principle, there is fewer contamination risk when the patients are scattered and not all together waiting in the same room.

There is two critical moments in the pairing of the patient flow and the radiopharmaceutical flow: the appointment and the patient's admission in the service.

«We cannot anticipate anything because we know only when the patient is already arrived ». « If a secretary did not admit the patients, I can't do anything, there is no information transferred in the software. And for the product orders, it is the same thing. In fact they are the ones who trigger the orders ».

5 types d'acteurs au sein du service + les patients :

Actors	Role and Activities
Medical Specialist in Nuclear Medicine	Ordonne l'acte medical pour un patient donné Interprète l'image
Radiopharmacist	Conçoit le radiopharmaceutique par le dosage du radionucleide et le vecteur associé en fonction du patient.
Laboratory technicians	Commande le radionucléide Réalise le dosage Gère le stock ?
Radiology technicians	Injecte le produit Fait l'image
Medical secretaries	Réalise le planning Admission et sortie du patient

Table 3: Actors identification.

The internal supply chain.

Figure X summarizes the flows of radiopharmaceuticals and of patients. Due to the short lifecycle of the product, the critical activity is the injection, since it relies on the synchronization between the radiopharmaceutical flow and the patient flow. All previous activities need to be done for both the flows to fit.

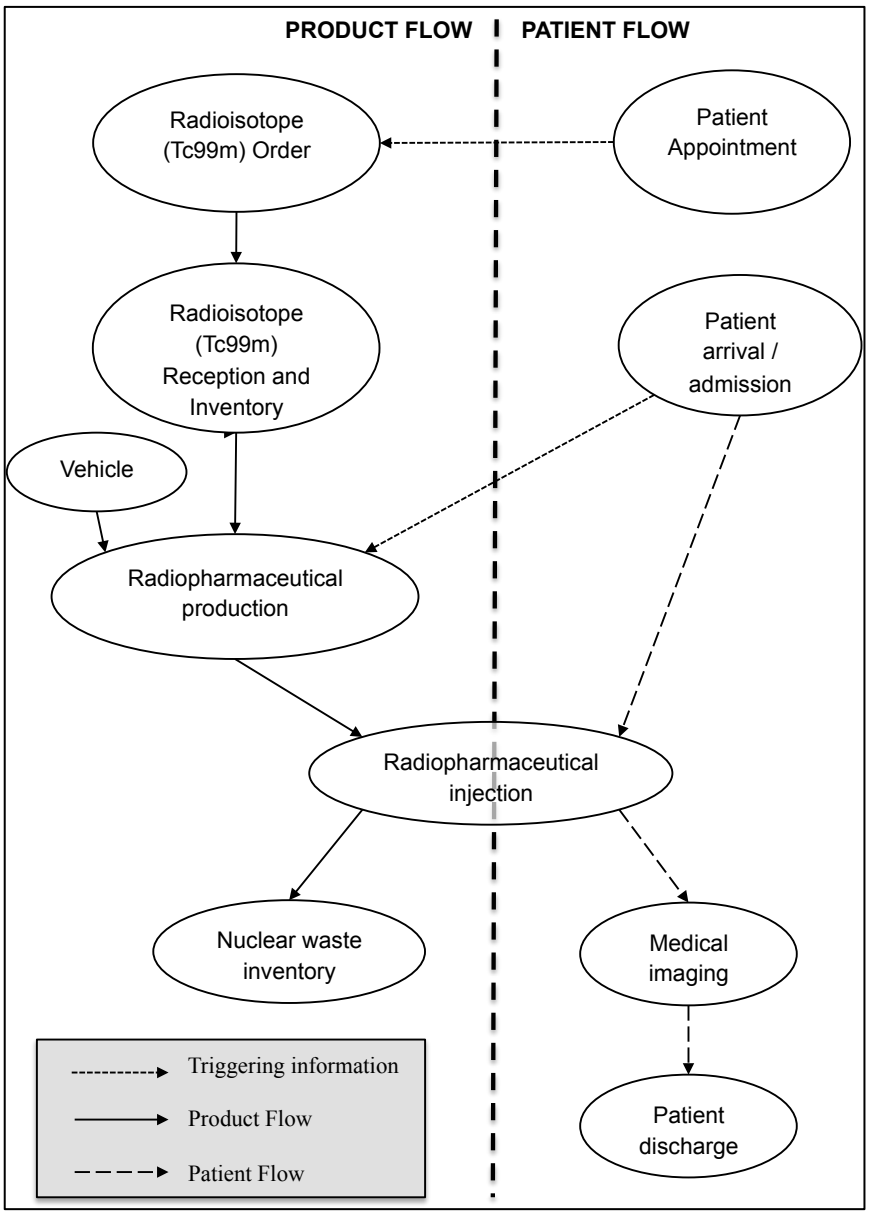


Figure : Flows pattern

2.2.3. Waste management

The radiopharmaceutical flow ends up with the waste management. In fact, the radiopharmaceutical preparation and use generate various types of radioactive waste. They have also various origins: hot laboratories, sanitation, examination rooms or hospitalization rooms. Collecting and sorting out this waste is done according to their radioactivity level.

1- Immediate local evacuation: waste, which has a very low radiation activity is then treated as a common waste with no radioactivity.

2- Postponed local evacuation: waste, which has a radioactivity half-life below 100 days. They are stored in a decay room to allow the radioactivity to decrease and to be able to manage them as ordinary waste eventually. This room adjoins the nuclear medicine service. The Head of radiation protection is in charge to empty the room on a regular basis.
3- Evacuation by the Andra of solid waste contaminated by radionuclides, which half-life is above 100 days.

« We put them here and this is the person skilled in radiation protection who empties it on a regular basis. Fortunately we almost use exclusively Technicium-99m…We still have a lot of bins. The girls, they have three, in the three rooms, I have one too, and so we fill them up quite quickly. He comes, he measures, if he finds zero radioactivity, it goes as ordinary trash ».

Regarding the generators specially, at the end of the week the laboratory technician put them in the airlock. From this moment, they are stored in the decay room and every Monday, the carrier takes back the two generators for which radioactivity level is compliant to the norms.
« We have a small airlock, for which the security staff opens the door and he delivers his parcels on a cart and if I put a generator ready to leave at that moment, this is when he takes it back ».

2.3. First findings: a localized representation of risks

Dans l'étude de cas, on peut faire ressortir deux risques majeurs dans la supply chain des radiopharma liés aux caractéristiques des produits. le premier sur les aspects de sécurité lies à la radioprotection atour d'un produit radioactif, le second sur la durée de vie d'un produit « personnel ».

Les risques associés à la chaine logistique des radiopharmaceutiques peuvent s'analyser au regard du couplage plus ou moins fort des flux produits et patient et des interfaces entre les parties prenantes de la chaine.

On peut ainsi distinguer les risques qui émergent d'une part, à l'interface des organisations notamment ceux liés aux interactions entre le fournisseur et le service de médecine nucléaire et, d'autre part, à l'interfaces des acteurs du service.

Interface fournisseur / CHUMN

Le risque auquel est soumis le service de médecine nucléaire est celui d'un défaut d'approvisionnement. Ce dernier peut avoir des causes différentes.

Le premier auquel le service est confronté, est celui lié à la pénurie du technétium. Cela arrive une à deux fois par an. Les réacteurs qui fournissent cet isotope sont d'une part vieux (plus de 40 ans) et peu nombreux dans le monde. Donc les industriels doivent faire face à des arrêts de production soit pour pannes soit pour maintenance. Le risque concerne en termes de conséquence le service de médecine nucléaire et les patients.

L'autre risque lié au fort couplage avec le fournisseur unique c'est un aléa dans la production conduisant à une non-conformité des produits et entrainant une annulation d'envoi de la commande.

Enfin, il peut y avoir un aléa dans le transport routier empêchant ou retardant la livraison.

« Nous avons un stock pour une semaine. Mais si jamais l'approvisionnement n'est pas prêt pour la semaine suivante, eh bien nous sommes très ennuyés ! Le TECHNETIUM a une période de 6 heures, le père, qui est le molybdène, a lui une période de 66 heures, donc en fait tous les trois jours ça diminue par deux, ce qui fait qu'on arrive vite en fin de possibilités, disons, pour nos besoins. On arrivera toujours à faire un petit quelque chose, mais il faudra limiter les examens, ça c'est sûr ! »

« Justement, par exemple, quand il y a eu de la neige, nous avons eu les générateurs avec 48 heures de retard, parce que tout était bloqué sur l'A1, donc ils n'ont pas pu faire la route !

Ça a impacté, nous avons donc travaillé avec l'autre générateur, heureusement que nous en avons toujours deux en permanence ! Nous avions également limité les examens. Il y a des examens que nous avons été obligés de reporter pour des raisons météorologiques ! »

Dans certain bien précis, il peut y avoir une entre-aide entre les trois services de médecine nucléaire du centre hospitalier pour faire face à un problème d'approvisionnement.

« On peut se dépanner de temps en temps, mais en réalité comme nous ne faisons pas les mêmes examens… C'est par exemple arrivé une fois qu'ils aient un souci sur un générateur ; il n'était pas efficace, ils avaient des élutions qui ne marchaient pas. Nous avons donc été obligés de fournir du TECHNETIUM. Nous pouvons arriver à faire ce genre de choses, mais c'est tout, car sinon tout est bien spécifique. »

Les autres risques sont générés aux interfaces des acteurs du service de médecine nucléaire.

Interface Médecin / secrétaires

Un premier risque se situe à l'interface des médecins et des secrétaires. A la demande de médecins, les secrétaires planifient parfois un rendez-vous ne respectant les délais de commandes du radiopharmaceutique. Deux raisons conduisent à cette désynchronisation des flux : la relation de pouvoir qui s'établit entre ces deux catégories d'acteurs et/ou l'absence de connaissances des médecins des délais de commande.

« Parce qu'elles aussi sont parfois impressionnées par le médecin qui veut l'examen tout de suite, elles demandent alors un produit, que je ne peux pas avoir avant telle semaine ! C'est rare parce qu'on est tous bien calés maintenant, mais c'est vrai qu'au départ, ce n'était pas toujours…

Et les médecins des services, ils ne savent pas comment on fonctionne, c'est normal. En fait nous changeons quand même régulièrement de marchés, ce ne sont donc pas les mêmes jours de livraisons, en fonction du commercial ou de la société. Ainsi, lors de ces changements, il y a toujours un petit peu de flottement, mais après c'est reparti pour trois ans ! »

Interface secrétaires / préparatrice

Un deuxième risque se situe celui-ci à l'interface des secrétaires et de la préparatrice. Les secrétaires prennent un rendez-vous mais la commande associée n'est pas passée par la préparatrice. L'examen ne peut donc pas avoir lieu.

« Tous les vendredis je leur demande de me sortir le listing qui recense tous leurs produits à commander. Ensuite je pointe sur mes bons d'accusés de réception, si oui ou non j'ai bien tout le monde. Vendredi je faisais un TP, car j'avais des élèves manipulateurs à former aussi, et donc, (soupir), le récapitulatif est passé à la trappe. Peut être que ça n'arrive que trois fois dans l'année, mais c'est dans ces trois fois là qu'il va y avoir un problème. Et donc là il y a malheureusement un patient qui est

venu, pour qui nous n'avions pas commandé de produits, donc il doit revenir la semaine prochaine »

Interface préparatrice / patient

Ce risque concerne les commandes ponctuelles et programmées, le produit est commandé mais le patient annule le rendez-vous. Le produit est alors perdu.

« On commande un produit pour le patient, le patient dit: "oh bien non, je n'ai pas envie de faire de traitement... on m'emmerde... j'ai peur." Donc là... il ne vient pas, il ne vient pas... hein... Puis il y a la négligence aussi... hein. le patient se dit: "oh, c'est un examen, ça va bien... je viendrais... ouais... j'ai rendez-vous... ah bien j'ai oublié."

L'autre cas qui survient, c'est quand le patient arrive, il est enregistré par les secrétaires. Dés lors, cette arrivée déclenche la préparation du radiopharmaceutique, mais pour différentes raisons, l'injection ne sera pas dispensée au patient et le produit sera perdu.

« Si le médecin de... prescripteur initial, c'est à dire le médecin de ville ou... heu... le médecin qui est dans le service, dit: "bon bien alors, Monsieur, vous allez passer une scintigraphie osseuse, vous avez rendez-vous tel jour dans le service." Le patient arrive. Et puis... heu... il n'a pris que sa demi-journée pour faire cet examen. Il arrive le matin, on l'injecte, mais l'imagerie se fait l'après-midi. Ça veut dire qu'il... comment il fait, lui ? Il a pris une demi-journée. Si on ne lui a pas dit que l'examen se déroulait sur la journée. Donc, il y a ça... heu... Donc, il est énervé... forcément, il n'avait pas prévu ça... donc déjà c'est des gens qui sont malades, donc... heu... voilà... ils ont aussi leurs "humeurs"... il y en a qui sont plus ou moins faciles, d'abord... et puis, bien si en plus ils voient qu'il y a une contrariété supplémentaire qui s'ajoute, bien il y en a qui disent : "oh bien si c'est comme ça... hop... ils vont aller se faire voir... hein... je m'en vais" »

Par exemple il y a eu un patient qui était « impiquable » la semaine dernière, chose rarissime aussi. Donc les anesthésistes sont venus, ils ont « titillé » pendant 2 heures le pauvre patient, il a fini au bloc, même au bloc ils n'ont pas réussi à trouver une veine. Donc du coup on a mis « Examen annulé, malade « impiquable ».

Dépendances / faibles couplages

Nouveau schéma (plus centré sur les acteurs que celui de Ponsard) et leurs relations.

Mise en avant de 2 flux : flux du patient / Flux du radiopharmaceutique → A rapprocher de Risques de santé / risque de productivité

Type of risk	**Identified risk**
Supply Risks	
Operational Risks	Inter-organizational Intra-organizational
Demand Risks	
Security Risks	
Macro Risks	
Policy Risks	
Competitive Risks	
Resource Risks	

Table 2 – Identification of types of risks in the ongoing case study

1. DISCUSSION AND CONCLUSION

Conceptual approach of risks: Gephart et al 2009

CONCLUSION

The paper aims at studying how organizational actors experience and understand transboundary organizational risks in the specific context of medical nuclear supply chain. The questions raised and the framework for analysis that we mobilize can be

tested in an abductive manner. In the final paper, we will present an exploratory case study in the domain of the medical nuclear supply chain. Our research method is based on interviews and on site observations. We expect that the paper will participate to the theoretical understanding of the inter-organizational risk management.

Empirical data that are being collected will provide a clear understanding of the risk management process. To go further and to identify potential improvement in the process, it seems also valuable to integrate considerations on information technologies the supply chain actors use to coordinate. Indeed, in addition to information consistency, information system integration enables the overall supply chain performance (Wong et al. 2011; Rai et al. 2006). Organizations have historically searched to enhance the integration of their information systems on regular logistics operations such as orders, shipments, or deliveries – i.e. the transactional information. Nowadays, some companies seek to go further in the integration of their information systems, either by integrating the exchange of strategic information (Klein and Rai, 2009) or by the use of more innovative applications. It will be interesting to identify in the specific case of medical nuclear supply chain if information systems that are used are adapted for managing risks.

REFERENCES

Aguilera, D.C., (1990), *Crisis intervention: Theory and methodology* (6th ed.). St Louis: Mosby.

Barton, L., (1993), *Crisis in organizations: managing and communicating in the heat of chaos*. Cincinatti: South-Western.

Carlile, P., (2004), “Transferring, Translating and Transforming: An integrative Framework for Managing Knowledge across Boundaries”, *Organization Science*, 15(5), 555-568.

Chopra, S., and Sodhi, S.M., (2004), “Managing risk to avoid supply chain breakdown”, *MIT Sloan Management Review*, 46(1), 53-61

Christopher, M., and Lee, H.L., (2004), “Mitigating supply chain risk through improved confidence”, *International journal of physical distribution & logistics management*, 34(5), 388-396.

Christopher, M., Peck, H., (2004), “Building the resilient supply chain”, *Industrial Journal of Logistics Management*, 15(2), 1-28.

Crowston, K., (1997), “A coordination theory approach to organizational process design”, *Organization Science*, 8(2), 157-175.

Emmons, H., (1968), “A replenishment model for radioactive nuclide generators”, *Management Science*, 14(5), 263-273.

Gephart, R.P., Van Maanen, J., and Oberlechner, T., (2009), “Organizations and risk in late modernity”, *Organization Studies*, 30 (2&3), 141-156.

Jüttner, U., Peck, H., and Christopher, M., (2003), “Supply Chain risk management: outlining an agenda for future research”, *International Journal of Logistics: Research and Applications*, 6 (4), 197-210

Klein, R., and Rai, A., (2009), “Interfirm Strategic Information Flows In Logistics Supply Chain Relationships”, *MIS Quarterly*, 33(4), 735-762.

Kumar, S., (2009). “Risk Management in Supply Chains”. *Advances in Management*, 2(11), 36-39.

Lee, H.L., Padmanabhan, V., and Whang, S., (1997), “Information Distorsion in a Supply Chain: The Bullwhip Effect”, *Management Science*, 43(4), 546-558.

Manuj, I., and Mentzer, J.T., (2008), “Global Supply Chain Risk Management”, *Journal of Business Logistics*, 29(1), 133-155.

Malone, T.W., and Crowston, K., (1994), “The Interdisciplinary Theory of Coordination”. *ACM Computing Surveys*, 26(1), 87-119.

Malone, T.W., Crowston, K., Lee, J., Pentland, B., Dellarocas, C., Wyner, G., Quimby, Y. J., Osborne, C., Bernstein, A., Herman, G., Klein, M., and O'Donnell, E., (1999), “Tools for Inventing Organizations: Toward a Handbook of Organizational Processes”, *Management Science*, 45(3), 425-443.

Mentzer, J.T., DeWitt, W., Keebler, J., Min, S., Nix, N., Smith, C., (2001), “Defining Supply Chain Management”, *Journal of Business Logistics*, 22(2), 1-25.

Nagurney, A., Nagurney, L., (2012), “Medical nuclear supply chain design: A tractable network model and computational approach”, *International Journal of Production Economics*, 140, 865-874.

Natarajarathinam, M., Capar, I., and Arunachalam, N., (2009), “Managing supply chains in times of crisis: a review of literature and insights”, *International Journal of Physical Distribution and Logistics Management*, 39(7), 535-573.

OECD, (2010), “The Supply of Medical Radioisotopes: An Economic Study of the molybdenum-99 Supply Chain”. Report. Nuclear Energy Agency.

Pearson, C.M., Clair, J.A. (1998), “Reframing crisis management”, *Academy of Management Review*, 23(1), 59-76.

Pettit, T.J., Fiksel, J., Croxton, K.L., (2010), “Ensuring Supply Chain Resilience: Development of a Conceptual Framework”, *Journal of Business Logistics*, 31(1), 1-22.

Ponsard, B., (2010), “Mo-99 supply issues: report and lessons learned”. 14th International Topical Meeting on the Research Reactor Fuel Management (RRFM2010), Marrakech, Morocco, 21–25March, published by the European Nuclear Society, ENSRRFM 2010 Transactions.

Rai, A., Patnayakuni, R., and Seth, N., (2006), “Firm performance impacts of digitally enabled supply chain integration capabilities”, *MIS Quarterly*, 30(2), 225-246.

Sampieri-Tessier, N., (2002), “Proposition d’une typologie des pratiques logistiques des hôpitaux publics français, enseignement à partir d’une etude empirique”, *Logistique et Management*, 10(1), 85-95

Tan, K.C., (2001), “A framework of supply chain management literature”, *European Journal of Purchasing & Supply Management*, 7(1), 39-48.

Tang, C.S., (2006), “Perspectives in supply chain risk management”, *International Journal of Production Economics*, 103(2), 451-488.

Wong, C.Y., Lai, K., and Cheng, T.E., (2011), “Value of Information Integration to Supply Chain Management: Roles of Internal and External Contingencies”, *Journal of Management Information Systems*, 28(3), 161-200.

World Nuclear Association (2009), Uranium and Depleted Uranium, http://www.world-nuclear.org/ Updated December 2009. Consultation January 2013.