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LEAN MANUFACTURING, HUMAN RESOURCE MANAGEMENT AND WORKER HEALTH: ARE THERE SMART BUNDLES OF PRACTICES ALONG THE ADOPTION PROCESS?

LEAN MANUFACTURING, MANAGEMENT DES RESSOURCES HUMAINES ET SANTE AU TRAVAIL : QUELLES COMBINAISONS DE PRATIQUES AU COURS DU PROCESSUS D'ADOPTION?

Rachel BOCQUET, Sandra DUBOULOZ, Tarik CHAKOR, IREGÉ, University Savoie Mont Blanc

Résumé

Les effets du lean manufacturing sur la santé au travail restent peu étudiés. Si des travaux récents montrent le rôle modérateur des pratiques de management des ressources humaines (MRH) sur cette relation, ils se focalisent le plus souvent sur quelques pratiques spécifiques et n'appréhendent pas leurs effets aux différentes étapes du processus d'adoption. En considérant le lean comme une innovation managériale, l'objectif de cet article est d'explorer la relation entre les pratiques lean, MRH et la santé au travail en prenant en compte explicitement la maturité lean de l'entreprise (i.e. intensité d'usage des pratiques et stade d'adoption). Les résultats, basés sur trois études de cas d'entreprises industrielles françaises, montrent que les effets du lean sur la santé au travail sont à évaluer à la lumière de combinaisons de pratiques lean et MRH qui diffèrent selon la phase du processus d'adoption.

Mots-clés: Pratiques lean, santé au travail, pratiques de management des ressources humaines, combinaisons de pratiques, processus d'adoption.

Abstract

The effects of lean manufacturing on worker health remain poorly understood. Although recent studies show a moderating role of human resource management (HRM) practices on this relationship, they focus only on some specific HRM practices and do not grasp their effects on the different phases of the lean adoption process. By considering lean manufacturing as a managerial innovation, the objective of this paper is to explore the relationship between lean, HRM practices, and worker health according to the firm's lean maturity (i.e. intensity of usage and stage of adoption). The results, based on three case studies of French industrial firms, show that the effects of lean practices on worker health should be assessed in light of the combination of lean and HRM practices that differ along the lean process.

Keywords: Lean practices, Worker health, Human resource management practices, Bundles of practices, Adoption process.

JEL: M10, M11

INTRODUCTION

Lean manufacturing (lean), whose foundation is the Toyota Production System, is one of the most important management innovations (MI) of the twentieth century (Birkinshaw, Hamel, Mol 2008). It has been positively linked to multiple dimensions of economic and operational performance (*e.g.* productivity, cost, quality and time) in the operations and supply chain management literature (Jasti, Kodali, 2015; Shah, Ward, 2003; Souza, Alves, 2018). However, its effects on employee health at work¹ (or, similarly, worker health) are less explored and remain contradictory (Bouville, Alis, 2014; Erdil, Aktas, Arani, 2018). These contradictory results may be due to the conception of lean adoption, which is too often restricted to a static perspective that does not take into account the different phases of lean adoption and tends to exclude human resource management (HRM) practices from the investigation (Bouville, Alis, 2014; Chanegrih, Creusier, 2016; Cua, McKone, Schroeder, 2001; Longoni, Pagell, Johnston, Veltri, 2013). Indeed, recent work in innovation management and human resource management highlights the fact that the integration of specific HRM practices can significantly moderate the effects of lean on health at work (Bertrand, Stimec, 2011; Dubouloz, 2014; Longoni *et al.*, 2013; Stimec, Bertrand, Michel, 2010). These studies provide some critical insight into the relation between lean and worker outcomes. However, exploring how lean and HRM practices are adopted remains a critical issue (Longoni *et al.*, 2013) since the combined use of HRM practices might not always be beneficial for employees (Ogbonnaya, Daniels, Connolly, Van Veldhoven, 2017).

This study addresses these limitations in two ways. First, it examines a full list of lean and HRM practices, in line with research that shows that considering bundles of practices can provide a more accurate understanding of lean effects (MacDuffie, 1995; Milgrom, Roberts, 1995; Ogbonnaya *et al.*, 2017). Second, it proposes a processual approach with the idea that various factors may differ according to the different stages of lean adoption (Damanpour, Schneider, 2006). To the best of our knowledge, no extant research investigates the relationship between lean and health at work, integrating a full list of lean and HRM practices in various stages of the adoption process. The current study addresses this research gap pertaining to the complex relationship between lean maturity (in terms of practices and adoption phases), HRM practices, and employee health at work.

Empirically, this research is based on a multi-actor qualitative approach using three case studies of French industrial companies that have adopted lean through the same regional lean program. A stabilized 2-D lean maturity matrix enables precise identification of the lean practices each firm has adopted (Shah, Ward, 2003), as well as their stage of adoption (Damanpour, Schneider, 2006). Moreover, the comparison uses a well-accepted list of HRM practices, in this case high involvement practices (HIPs) (Guerrero, Barraud-Didier, 2004; Lawler, 1986). Finally, objective measures of worker health control for potential biases inherent in respondents' subjective scores (Bäckström, Ingelsson, 2015).

Results confirm the moderating role of HRM practices on the relationship between lean and employee health at work. They also show that the effect of lean practices on health depends not on the intensity of the lean and HRM practices firms adopt but rather on the combination thereof. Interestingly, the bundles of practices differ according to the stage of lean adoption.

¹ We focus on the concept of employee health at work or worker health (Bäckström, Ingelsson, 2015; Bouville, Alis, 2014; Longoni *et al.*, 2013) that is commonly used in the literature, suggesting that the relationship between lean and worker outcomes (job satisfaction, health at work, employees' intention to stay) is related to the manner in which lean is implemented (Bertrand, Stimec, 2011; Bouville, Alis, 2014; Longoni *et al.*, 2013). This conception of employee health at work is in line with the World Health Organization's definition (1946, p.100) as '*a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity*'. This conception has the advantage of addressing health at work in both its positive and negative connotations.

In the early stages of the adoption process, a purely theoretical and technical approach to lean still prevails, with negative consequences for worker health. After this stage, companies are able to make adaptations (Ansari, Reinecke, Spaan, 2014) using HRM practices in conjunction with lean practices. These adaptations are generally made during the advanced stages of the adoption process (*i.e.* the implementation and routinization phases). They lead to an integrated system that is more conducive to worker health.

Overall, this research advances the literature in two ways. First, using a multi-dimensional processual approach to lean, it provides a better understanding of the effects of lean practices on worker health throughout the adoption process. Second, it contributes to the literature on MI by considering the link between this specific type of innovation and an insufficiently studied dimension of firm performance, namely social performance.

LITERATURE REVIEW

Lean is a noteworthy managerial innovation (MI) (Birkinsha *et al.*, 2008; OECD, 2005) whose foundation is the Toyota Production System (Shah, Ward, 2003). Mol and Birkinshaw (2009) define MI as the adoption of management practices, process, structures or techniques new to the firm that are intended to further organizational goals. This innovation is composed of three building blocks, called the 3Ps (Mamman, 2009): philosophy, principles and practices/techniques. It is generally defined from a philosophical perspective, related to guiding principles and overarching goals (Womack, Jones, 1994), or from a practical perspective, describing a set of management practices, tools or techniques that can be observed directly (Shah, Ward, 2007). The philosophy of lean focuses on avoiding cardinal waste, continuous improvement processes, and respecting customers, employees and suppliers, which constitute its guiding principles (Shah, Ward, 2007).

Although no unified definition of lean is accepted, some authors (Cua *et al.*, 2001; Jasti, Kodali, 2015; Pettersen, 2009) have compiled a comprehensive list of lean practices. Cua *et al.* (2001) identify 29 practices and propose to cluster them in four bundles: total quality management (TQM), just in time (JIT), total productive maintenance (TPM), common practices linked to leadership and strategic management practices (see *Table 1*).

Table 1 – Lean manufacturing: philosophy, principles and practices

PHILOSOPHY	PRINCIPLES	PRACTICES
To avoid cardinal wastes and respect customers, employees and suppliers	<ul style="list-style-type: none"> • Waste elimination • Continuous improvement • Customer focus 	<ul style="list-style-type: none"> • TQM practices • JIT practices • TPM practices • Leadership and strategic practices

Identifying lean practices that organizations already use is an effective initial step to assess the level of integration of the lean approach in organizations. Some authors go further by evaluating the level of maturity regarding actual use of lean practices. For each practice, Lyonnet, Pillet and Pralus (2010) propose evaluating its intensity of use in the organization using the NEMSE method: the practice is scored as Non-existent or Existent, implemented with a method likely to be generalized (Method), handled methodically, effectively and systematically (Systematic), or its application is efficient and should be communicated (Exemplary).

Beyond the number of practices and their intensity of use, the literature on MI also suggests retaining its adoption phase to evaluate the level of MI maturity. The process of MI adoption can be grouped into three more general phases: (1) *Decision*, which involves becoming aware

of a problem, searching for existing innovation, seizing and evaluating opportunities, benefits and suitability, choosing the best ones and allocating the necessary resources; (2) *Implementation*, which consists of activities, events and tactics that pertain to the internal actors' acceptance of MI, being skilful and committed in its use and adapting it; (3) until it becomes an organizational routine (*Routinization*) (Damanpour, Schneider, 2006). The MI adoption is thus conceptualized as a rational and linear process. However, some authors propose to nuance this rational view incorporating the possibility of recursions, intertwined and repeated cycles throughout this process (Zbaracki, 1998). Here, we take this approach and consider that lean maturity can be evaluated along its intensity of use, as well as its phases of adoption.

Lean and worker health

Findings are still contradictory regarding the effects of lean on workers (Bruère, 2014; Longoni *et al.*, 2013). A considerable body of research addresses the *negative effects*. Some studies underscore its impact on work-related musculoskeletal disorders (Brännmark, Håkanssona, 2012; Landsbergis, Cahill, Schnall, 1999; Treville, Antonakis, 2006). Lean is also linked with increased injuries, and job depression (Conti, Angelis, Cooper, Faragher, Gill, 2006), pain, discomfort (Saurin, Ferreira, 2009), high blood pressure, hypertension, cardiovascular disease, psychological strain and distress (Sprigg, Jackson, 2006). Other authors examine the effects of lean on health at work through job satisfaction, showing a significant association with psychosomatic health complaints, stress-related ill-health symptoms, and depression. These negative effects result from the continuous need to develop new capabilities and to improve productivity (Brenner, Fairris, Ruser, 2004). Reducing time cycles increases work intensity, repetitive movements, worker effort, and work-related stress (Kaminski, 2001; Landsbergis *et al.*, 1999). Furthermore, the combination of increased task variation and lack of competence increases physical stress, risk for disorders, and difficulties in filling production goals (Christmansson, Fridén, Sollerman, 1999). These ill health complaints also pertain to white-collar work, traditionally considered 'safe' jobs (Carter, Danford, Howcroft, Richardson, Smith, Taylor, 2013).

By contrast, some studies have shown some *positive effects*. Wellbeing outcomes and the beneficial effects of lean include job satisfaction, team working, collaboration and employee involvement, the opportunity to develop multiple skills with job rotation, greater autonomy of responsibility, innovation, intrinsic motivation, organizational citizenship, promotion of ergonomic and secure workplace design (Brenner *et al.*, 2004; Conti *et al.*, 2006; Hasle, Bojensen, Jensen, Bramming, 2012; Kaminski, 2001; Perez Toralla, Falzon, Morais, 2012; Seppälä, Klemola, 2004; Souza, Alves, 2018; Womack, Armstrong, Liker, 2009). According to Longoni *et al.* (2013), the adoption of lean practices has positive effects on operational and health performance. Jackson and Mullarkey (2000), and also Seppälä and Klemola (2004), show increased breadth of employees' role, cognitive demands, better skill utilization, and relations that are more social.

Still more studies show *both negative and positive effects*. Conti *et al.* (2006) show that lean practices increase work intensity, resulting in a negative effect for employees, but those that increase employees' influence and support have a positive effect. Jackson and Mullarkey (2000) also identify both effects in terms of autonomy, physical demands, and social climate. Similarly, Bouville and Alis (2014) show that some lean practices (*e.g.* delegation of responsibilities, problem-solving demand, standardization, job rotation) have negative consequences for job satisfaction, employees' intention to stay, and health at work, while others (quality management) are positively linked to these social outcomes.

The literature provides three main explanations for these inconsistent findings. First, lean conceptualizations vary among studies (Hasle *et al.*, 2012; Parker, 2003). Although consensus on practices associated with lean has emerged, studies rarely take into account a full menu of lean practices or the level of lean maturity (Saurin, Ferreira, 2009). Second, research results are unstable due to methodological inadequacies, which do not control for potential moderators (*e.g.* an organization's context, culture, management choices) (Conti *et al.*, 2006; Parker, 2003; Saurin, Ferreira, 2009). Third, in some cases, ideological bias has been detected (Schouteten, Benders, 2004).

More recently, to understand the lean effects on worker health, some studies have explored the role of HRM practices as significant moderators (Longoni *et al.*, 2013). Following this strand of literature, this study embraces the idea that although lean is inherently stressful and worker wellbeing deterministic, its effects can be balanced with the recognition that HRM practices could play a crucial role.

The role of HRM practices on the relationship between lean and worker health

Conti *et al.* (2006) show that the relationship between lean and worker job stress is not linear, depending on management decisions in designing and operating lean systems. Other studies have examined the moderating role of several HRM practices, such as spaces for discussion (Bertrand, Stimec, 2011; Detchessahar, 2003; Stimec *et al.*, 2010), practices associated with joint regulation between employer and union (Bruère, Bellemare, Caroly, 2018), employees' involvement (Conti *et al.*, 2006; Hasle *et al.*, 2012; Perez Toralla *et al.*, 2012), or training (Kaminski, 2001). All these HRM practices are positively linked with increased worker health. These studies have been criticized for considering HRM practices separately. Indeed, recent studies have shown the ineffectiveness of examining only a single type of HRM practice when studying HRM's influence on system or employee outcomes. For example, comparing the integrated and isolated effects of high-performance work practices on employee health and wellbeing, Ogbonnaya *et al.* (2017) find evidence that the integrated effects of HRM practices have additional explanatory power over employee outcomes above their isolated effects. However, their study does not relate specifically to a context of lean adoption.

Other studies on lean support this view by providing a careful examination of the relationship between HRM and lean practices. MacDuffie (1995) shows that a bundle of 'high-commitment' HRM practices associated with lean practices positively affects plant performance in both productivity and quality. Extending the menu of HRM practices common to TQM, JIT and TPM technically-oriented practices, Cua *et al.* (2001) show that different configurations of practices, both socially- and technically-oriented, can improve organizational performance. Based on similar practices, Longoni *et al.* (2013) provide a nuanced perspective of the effects of lean on both operational and worker health and safety performance when a lean adoption model made of bundles of HRM/lean practices is at work. Together, these studies confirm that HRM practices should be implemented as interrelated elements in a bundle of HRM practices, complementary to the lean practices bundle. However, they restrict their investigations to certain high-commitment HRM practices or HRM practices common to lean programs, while a satisfactory study of complementarities between bundles of practices requires a full set of HRM practices (Milgrom, Roberts, 1995). Therefore, the current study adopts a broader definition of HRM practices to ensure that no practice is omitted. In line with Guerrero and Barraud-Didier (2004), the study considers High-Involvement Practices (HIPs), which consist in gathering intelligence, ideas and the motivation of all workers. Because HIPs are a source of motivation and commitment for employees, they are positively related to performance dimensions (Guest, 2001; Lawler,

1986) such as social performance (Guerrero, Barraud-Didier, 2004). One of Guest's (2001) key findings is that the impact of HIPs on social performance is stronger when they are combined into a bundle rather than taken in isolation. Recently, Ogbonnaya *et al.* (2017) obtained a more nuanced result depending on the coverage of practices associated with employees' experience of work intensification. Concerning HIPs, Guerrero and Barraud-Didier (2004) identify four categories of core practices widely accepted in the literature: (1) training and skills development practices, (2) motivational incentives and recognition practices, (3) communication and information sharing practices and (4) participation and empowerment practices. We therefore consider this full set of HIPs (see *Table 2*).

Table 2 – A full set of HIPs

HIPs	DEFINITION
<ul style="list-style-type: none"> • Training and skills development 	Practices aimed at acquiring new skills, developing collective competences and organizational learning
<ul style="list-style-type: none"> • Motivational incentives and recognition 	Practices aimed at rewarding group and employee efforts, including monetary compensation and non-monetary compensation
<ul style="list-style-type: none"> • Communication and information sharing 	Practices aimed at improving communication between groups of employees in terms of content of information or information management, from the top down or from the bottom up
<ul style="list-style-type: none"> • Employee participation and empowerment 	Practices aimed at sharing power and promoting employees' autonomy through task enrichment and work organization

In sum, there is still neither consensus on the effects of lean on worker health nor on the potential moderating role of HRM practices. Prior studies focus only on some specific HRM practices and consider the transition process to lean as a whole without distinguishing between its different adoption phases (Martínez-Jurado, Moyano-Fuentes, Gomez, 2013). Therefore, the aim of this study is to take a first step towards a better understanding of the effects of lean on worker health by taking into account a full set of lean and HIPs and their potential combinations throughout the different phases of the lean adoption process.

METHODOLOGY

We use a qualitative methodology, which is well-suited to our exploratory objective (Eisenhardt, 1989).

Case selection

Since our objective is to explore the relationship between lean, HIPs and worker health by considering lean maturity (in terms of practices and adoption phases), we selected three manufacturing companies, which have all adopted lean, but at distinct levels of maturity. All companies adopted lean with the support of the same regional programme, called 'industrial excellence'. This program² was designed to help regional firms to adopt lean 'best practices' in order to improve their overall operations in a sustainable manner. Companies that joined

² In this program, nothing is imposed in terms of objectives to be achieved and procedures to be implemented. Companies are called upon to define strategic priorities that are broken down into individual objectives distributed throughout the organization. Emphasis is placed on establishing a robust problem-solving process by highlighting problems through standards. An educational process is planned for encouraging the involvement of all. Only operational gains are measured.

the program received personalized assistance from a lean consultant for a period of two years. To provide a robust assessment of each company's lean maturity, we proceeded in two ways. First, we drew upon the knowledge of consultants who supported the studied companies³. Second, each managing director completed a self-assessment grid comprising the two dimensions of lean maturity: intensity of lean practices used (number of lean practices adopted among a full menu of 32 practices and their intensity of use, which produces a score) and phases of adoption achieved. We then applied the following criteria to ensure triangulation (Miles, Huberman, 1994): cases giving us access to several types of informants (internal and external, from different status) and internal documents. Table 3 gives an overview of the three cases selected, which are presented below.

Table 3 – Sample characteristics

Firms	Industry	Employees	Turnover (K€)	Net profit(K€)	Total equity (K€)	Financial rate of return (%)	Lean Maturity 2014			
							Intensity	Phase ⁽¹⁾		
A	Metallurgy	2017	1 500	597 700	17 750	237 316	7,5	2.87	R	R
		2015	1 500	602 950	5 970	202 370	3			
B	Chemical industry	2017	295	62 938	233	18 016	1,3	3.54	I	I advanced stage
		2015	289	45 102	1 053	17 488	6			
C	Equipment and machinery manufacturing	2017	30	7 936	984	5 597	17,6	2.45	I	I first stage
		2015	28	5 645	413	4 060	10,2			

Phase ⁽¹⁾: Classification from the respondents' responses in the left-hand column; classification from the consultants' responses in the right-hand column.

Brief description of the three cases

Company A: Created in 1909, Company A is a world leader in stainless steel long products. With its recognized business-specific and technological expertise, it has a strong position in an environment that remains challenging and uncertain. It produces and sells a wide range of products such as bars, wire rods and wires used in automotive and aerospace industries, the medical field, oil and gas production. Company A has always been oriented toward profitability and has a long history with lean: TQM, TPM and World Class Manufacturing, renamed as an internal label in 2006. The majority of lean practices were handled

³ The two consultants who were called before the beginning of the study (in 2014) helped us to select the companies according to our main theoretical criteria of selection (*i.e.* being involved in the industrial excellence regional program and having adopted lean, but at distinct levels of maturity). These experts provided us with a first assessment of each company's lean maturity, which was refined with the three companies' managing directors. Although we did not have privileged relationships with them, they accepted to be interviewed three years later. The opportunity for them to access our research results provided a strong incentive to respond. We thus obtained additional information on the situation of the companies studied (in 2018), in particular on lean effects, both in terms of economic and social performance

methodically, effectively and systematically. Company A has reached the stage of routinization and a high level of maturity in terms of lean practices from self-assessment (2.87/5), while this score is clearly under-estimated in the consultant’s view. *‘This was the first time I worked with a company with this level of maturity, much better than XX [another emblematic company with regard to lean adoption], which set standards’* (Consultant A). The consultant reinforces this idea, explaining: *‘in spite of its successive buyouts, the fundamentals are there and lean adoption has never been called into question’* (Consultant A).

Company B has been part of a French pharmaceutical laboratory since 1996. It is organized as an independent profit centre with its own product area. It is a wipes maker in Europe, specialized in cosmetics. In a highly competitive environment, Company B focuses on cost-reduction and quality improvement. It also seeks to reduce musculoskeletal disorders that are closely related to the activity. Using the ISO 9001 quality standard as the starting point in 2008, Company B went further by adopting lean (or ‘continuous improvement’) without any support from its group. Today, Company B is still in the implementation phase with an intermediate degree of use of lean practices. The CEO’s score of lean maturity (3.54) appears to be somewhat overvalued in light of the consultant’s assessment. *‘We’re talking about a slow process of adoption in this company’* (Consultant B).

Company C is an industrial manufacturer specializing in automatic assembly. It was created in 1978, following the acquisition of a French company skilled in wood assembly by a German group specializing in metal assembly. Company C provides a service on joining methods used in mass industrial production for several sectors such as automotive, electrics, electronics and telephony. It benefits from very favorable market conditions, in particular due to growth in the automotive sector. The firm adopted lean in 2012, based on its ISO 9001 quality standard, and is still at the beginning of the implementation phase: about half of the lean practices were implemented, exhibiting a low intensity of use. Compared with respondents’ and the consultant’s statements, the CEO’s lean maturity perception seems overvalued (score = 2.45/5). *‘The functional base from which this company started was too low and very little progress has been made’* (Consultant B).

Data collection and interview protocol

While lean adoption is treated herein as a complex phenomenon encompassing not only diverse practices but also multiple actors, we chose a multi-actor approach and selected respondents who were likely to play a significant role in the lean adoption process, regardless of whether they are operating at a strategic or operational level. For each company, six to nine people were engaged in a rigorous protocol of semi-directed interviews (see *Table 4*).

Table 4 - Interviews conducted

Company	Industry	Number of interviews	Respondents’ positions	Additional data
A	Metallurgy	8	Industrial directors (2); human resource manager (1); middle managers (2); operators (3)	Social Balance Sheet Data Lean Self-assessment Intervention reports
B	Chemical industry	8	General director (1); human resource manager (1); quality manager (1); lean manager (1); middle managers (2); technicians; operators (2)	

C	Equipment and machinery manufacturing	6	CEO (1); administrative and financial director (CFO) (1); quality manager (1); middle manager (1); operators (2)
REGIONAL PROGRAM		2 at two times	Consultant (2)
			Intervention and project reports

The interview grid consisted of the following themes: (1) characteristics of the respondent, (2) organizational and managerial characteristics, (3) presence or absence of HIPs (in relation to the full set described in Table 2) at the organizational and workplace levels, (4) lean maturity in terms of practices and phases of adoption and (5) lean and worker health (perceived effects). All interviews took place in the workplace to shed light on the respondents' direct environment. The 25 completed interviews lasted one hour on average, resulting in 27 hours of recording and 290 pages of transcripts.

To complement the primary data, internal and external secondary data were also collected. First, both internal and external sources have proven essential to complete the lean maturity diagnosis provided by consultants and respondents. Second, worker health indicators within a three-year period (2012–2014) were also collected from each company (see *Appendix A*). These indicators are in line with the concept of employee health at work or, similarly, worker health that we retain in this research (Bäckström, Ingelsson, 2015; Bouville, Alis, 2014; Longoni *et al.*, 2013). All these indicators were valuable to corroborate subjective information gathered during the interviews and to make comparisons (Yin, 2009). Moreover, each participant responded to a series of seven questions (measuring job satisfaction, health at work, intention to stay) at the end of the interview that were formulated using Bouville and Alis (2014)'s constructs (see *Table 5*). Finally, secondary external sources (websites, newspaper articles, reporting of consultants' interventions, companies' progress and results) were helpful in shedding light on the economic environment and results of the companies under study.

Table 5 – Constructs operationalization

Construct		Operationalization	Authors
LEAN MATURITY	In terms of practices	32 lean practices auto-assessed by companies through the NEMSE method	Cua <i>et al.</i> (2001); Lyonnet, Pillet, Pralus (2010); Pettersen (2009); Shah, Ward (2007);
	In terms of adoption phase	Phase indication for each lean practice: DECISION, IMPLEMENTATION, ROUTINIZATION	Damanpour, Schneider, 2006; Klein, Sorra, 1996.
HIPs		Four bundles: TRAINING AND SKILL DEVELOPMENT, MOTIVATIONAL INCENTIVES AND RECOGNITION, COMMUNICATION AND INFORMATION SHARING, EMPLOYEES' PARTICIPTION	Guerrero, Barraud-Didier, 2004; Guest, 2001; Lawler, 1986;
WORKER HEALTH	Objective measures	HUMAN RESOURCE INDICATORS (all provided over 2011–2013): number of departures depending on status, turnover (in percentage), number of days lost due to workplace accidents, number of days lost due to illness, number of occupational illnesses; expenditure on continuing education (in percentage); Expenditure to improve working conditions, number of hygiene and safety committee' meetings, and main issues addressed	Hurrell <i>et al.</i> , 1998, Ulrich, 1997
	Subjective measures	Seven questions administrated at the end of each interview to evaluate:	Bouville, Alis, 2014

(perceptions) JOB SATISFACTION: (1) 'On the whole, I am satisfied with my job'; HEALTH AT WORK: (2) 'My work is rather harmful to my health' (3) 'My work is rather detrimental to my health' (4) 'I sometimes cannot sleep because of my job'; (5) 'My work is tiring'; (6) 'My work is stressful'. INTENTION TO STAY: (7) Do you intend to change work positions or jobs?'

Data analysis

Content analysis was performed. To do so, all data collected were double coded according to the aforementioned themes and related sub-themes. Two researchers were involved at each step of coding and their work was checked by a third one. Coding was not considered complete until all three researchers reached consensus.

RESULTS

Consistent with our aim, the results on the relationship between lean, HIPs and worker health are presented according to the different phases of lean adoption.

Decision Phase

The three companies justified their decision to adopt lean on the grounds that they expected to achieve better operational results, even though Firm B was also preoccupied by the growing problem of musculoskeletal disorders in its workers. *'Our objective was to link continuous improvement to versatility because employees' versatility avoids too many repetitive actions and is a solution to the growing problem of musculoskeletal disorders'* (B - CEO).

Among the intended operational results, 'ongoing improvements in processes and products', 'an increase in overall equipment effectiveness', 'waste reduction' (including the reduction of useless steps in the workshops at Company B), 'improvements in the quality of service' (service rate) and 'customer satisfaction' were the most cited by the three companies. The financial return objective remained the most frequently cited reason by the three firms. For Company B, the firm's profitability was perceived as a necessity for survival given the requirements imposed by its group. To deal with these needs, lean appeared to be a ready-made solution, all the more so because external consultants could help them in their actions. *'Our primary focus was the economic aspect of the company, in particular cost reduction. So, at the decision stage, costs were a strong axis. The second strong point, which is partly related to costs, but not only this, was the satisfaction of our customers, which is the quality aspect.'* (A - Industrial director 1)

'Being able to do this with external assistance, through training, using lean tools, in a more progressive way, was important in our decision.' (C - Quality manager)

At this stage of decision-making, with the exception of a few internal actors, all the companies discovered lean principles and practices through the regional program. The directors and some managers said that they read press articles or media reports on lean manufacturing success stories and best practices. As a result, the decision to adopt lean followed a top-down approach that was quite theoretical. The lean philosophy was

production-focused, mainly on tools and technical practices, without any notion of issues related to management.

'The approach was initially instituted by the steering committee, accompanied by black belts. They gave us a list of tools, with things that may have been directive at first; our more general concern was to develop the involvement, to disseminate the tools. So, we pushed people to use the tools: "do a SMED, do a Kaizen, do a 5 why".' (A- Industrial director 2)

Thus, at this stage, lean was perceived as an instrumental system to solve operational difficulties and financial challenges without any managerial foundations. The ignorance of most internal actors led the companies to hold simplistic and theoretical expectations about lean.

Implementation Phase

The decision phase undoubtedly had consequences on the implementation phase, which could not be considered as a whole process. Our results show different steps of maturity within this phase, with specific effects on worker health.

Step 1: Lean as an instrumental and technical system with negative effects on worker health

Because of the decision phase's turn of events, the first step of the implementation phase was designed on lean theory based on a methodology that adhered to key lean principles, scrupulously modelled on what had been done elsewhere, and involving carefully imitated, 'formatted' practices.

In **Company A**, the first step of implementation was a source of tension among employees as well as managers: *'At the beginning, we first experienced phases that were somewhat summary, poorly prepared, poorly supported, which resulted in semblances of things, failures that ultimately destabilized the employees of the company'* (A - HR manager). The focus was clearly on technical lean tools, and the human side was overlooked. This focus had a negative effect on employee wellbeing: stress for the managers who had to follow indicators with which they were not particularly familiar; unease in the operators and technicians who had to use tools and methods that did not make sense to them; employee difficulties in, or even resistance to, adopting unilaterally imposed methods; disinclination on the part of the workers and a tense work atmosphere between the workers who willingly used the lean methods and tools and those who were reluctant to use them.

In **Company B**, when lean was first put into use, no more than 10 people were involved, mainly employees in charge of production lines, technicians, and top managers. All of them attended training sessions led by external consultants. Implementation was difficult given the limited amount of managerial resources allocated. The lean manager, also responsible for purchasing, admits to becoming overwhelmed by the amount of work: *'Many improvements could have been resolved through brainstorming and other lean tools. Unfortunately, I had a little bit of trouble keeping up because of my heavy workload in purchasing tasks'* (B- Lean Manager). This difficulty was reinforced by the structure of the company, which has no middle management, and by values that are more declared than shared. Shared philosophy and principles of lean were not established within the company, especially because of the top-down decision to adopt lean. While some people associated lean with good manufacturing practices oriented towards customer satisfaction, others associated it with principles oriented towards productivity, quality or waste reduction. For some operators, lean represented something external to their workplace: *'I don't see lean in my work'* (B - Technician). One respondent noted that practices related to continuous improvement, JIT or quality were not

systematic: *'I do not have the time to do preventive maintenance. It is a black spot'* (B - Technician). Company B also saw lean as a solution to the growing problems of workers suffering from musculoskeletal disorders but did not consider the necessity of including HIPs. It only placed a strong emphasis on versatility, job rotation and autonomy to facilitate fast hand-offs and make jobs less difficult. Lean had no effect on schedules, but hand-off times were greatly optimized, as was working pace. This is one of the positive effects of lean on worker health, but it was low because Company B had not realized the consequences of the just-in-time phenomenon, through ignorance. *'It may be a little tenser. Because in fact, the flow is tighter, so necessarily ...'* (B - HRM).

In **Company C**, the first steps of lean implementation were marked by dissonances and misunderstanding about lean. For the CEO, 'lean' was just a word for a global process of continuous improvement or *'only a theory'*, not achieved in the field. He underscored the disconnection between the quality approach supported by the quality manager, and lean supported by a line manager. Lean philosophy was not shared throughout Company C. The CEO still believed that *'experts'* (here, the quality manager) must think about the work while others execute. This lack of experience with lean led to oversimplification. This in turn led to the production and consumption of lean without an in-depth grasp of its underlying foundations. Few HIPs were in place, and they were not considered as necessary for lean implementation. Furthermore, the CEO *'lacked a delegating style'* (Consultant B) and there were some difficulties within the executive committee. *'In short, it was a can of old crabs'* (Consultant B). Training and skills development were limited and disconnected from the lean process. The CFO denounced the mismatch between firm needs and training, noting the latter was *'made to please everyone'*. In fact, Company C had just begun to set up individual interviews initiated by the CFO: *'We try to ask them questions, to target, with open questions, to make them talk'*. This initiative surprised some operators, who were not used to talking about their work. Motivational incentives and recognition practices remained limited and widely non-formal. The line manager tried to increase daily team recognition. *'Recognition? It is given every day by being present and available'* and by promoting some employees *'in relation to what guys have done ... but the board has unfortunately declined all my requests'* (C - Middle Manager). Finally, communication and information sharing in Company C was largely informal: billboards near the coffee machine communicated training and *'a mini corporate network that everyone can access to publish some interesting news'* (C - CEO). The CFO reported a lack of management and several organizational dysfunctions.

Step 2: First difficulties related to the addition of high-involvement practices to lean

As noted above, all three companies reported difficulties and negative effects on employee wellbeing in the preliminary stages of implementation: stress; unease in the operators and technicians; resistance to adopting unilaterally imposed methods; feeling overwhelmed, especially for managers; feeling helpless; work intensification because of just-in-time production; dissonances and misunderstanding about lean; lack of management support. These first steps led two of the three companies to re-examine the way that they managed its adoption. Therefore, HIPs were gradually integrated into lean practices and methods more or less successfully, depending on the companies.

Company A adopted several HIPs that were increasingly incorporated into the lean approach. Amongst these HIPs, Company A first adopted participative practices such as workshops to involve all employees in the new definition of work procedures. *'When you are in a working group, you can be consulted. And, lastly, we can influence decision-making.'* (A – Operator 1). Second, the firm renamed lean to use an internal label: Atlas. *'I think that the change of name is an element that nevertheless contributes to the appropriation of the approach. It was*

necessary to give a connotation from our universe' (A – Middle manager 1). Formal communication practices were developed, with meetings at several levels and time scales. The workshops organised around Atlas projects were also opportunities for discussions and for sharing information, achievements, shortfalls, and emerging issues. *'The working groups around the Atlas pillars are motivating for them [operators]. They are meeting points, places for discussions. They are keen on that.'* (A – Middle manager 2). The employees valued the 'bottom-up' and participatory orientation of these workshops: *'It's basically top-down, we're not going to hide it ... except the workshops. That is why they are so important for them [employees]'* (A- Industrial Director). Company A also developed a dynamic ad hoc training program focused on the Atlas approach. In 2014, 2.9% of the wage cost was devoted to training compared with 2.8% in 2013 and 2% in 2012. Some specific training was also developed for managers to help them to deal with Atlas practices, methods and indicators and lead working groups. Last, the degree of maturity both in terms of lean and HIPs of Company A was reflected by a growing awareness of the importance of including a grasp of health and safety issues. A specific pillar of the Atlas approach was developed on this focus, which became a central element. Specific indicators of health and safety were communicated and analyzed daily. Regular safety audits, effort studies and stress enquiries were performed. *'In the Atlas program there are 12 pillars. The health and safety pillar is now the most important one. Therefore, yes, it is totally integrated'* (A – Operator 3).

Company B put in use some lean practices, while maintaining a work organization in which the degree of employee autonomy remained limited, due to the precise standards, highly standardized procedures, and strict quality control system. Indeed, Company B can be considered as a hybrid system since it included lean practices that coexisted with a Taylorian philosophy and principles. Employees noted thresholds above which they had no decision-making power: *'When serious problems arise, the decision is no longer in my hands'* (B – Operator 2). The managerial maturity of Company B appeared to be weak. The lack of managerial practices was partly offset by managerial proximity with top managers. First, training and skills development was mainly based on a peer training support system. Trained technicians provided the basic tasks and procedures to operators in charge of production lines, who in turn provided their know-how and interpersonal skills to other operators. While trainers regarded this system as beneficial to their own work, trainees were more critical, considering that *'training could include other aspects than [technical] manufacturing operations; it is something we know how to do very well!'* (B - Operator 1). Social data confirmed that efforts in terms of continuous training did not increase during the 2012–2014 period. Company B had no annual individual interviews, motivational incentives or recognition practices because *'the company's management doesn't want that'* (B - Quality Manager). Employees expressed frustration and demotivation: *'It's really a lack of symbolic gestures. I would say that it discourages me'* (B – Operator 2). By contrast, other employees saw increased responsibility as a benefit despite low wages. Furthermore, apart from billboards in the shop area, communication remained informal. A consequence is the overload of certain top managers or committees. In the absence of team or workshop managers, the chief human resource officer had to deal with all types of problems on the work floor. Moreover, the lean manager admitted that the works council, as well as the hygiene, safety and working conditions committee (HSWCC), had become 'catch-all' bodies because employees did not know from whom or where to get information.

Concerning worker health, practices such as versatility, job rotation and teamwork made work less difficult. However, all the health and security issues were entirely delegated to the HSWCC. Its annual budget amounted to €250,000 for 2014 (compared with €150,000 for 2012). In this context, quarterly meetings with occupational physicians and ergonomists were organized and seemed to produce positive effects: *'I would say that about half the requests*

led to something.' (B - Lean Manager). Employees were more critical as the focus was more on safety with the diffusion of information (about the right movements to use) and the acquisition of new machinery and equipment that made work less difficult but that were not often used. However, *'what has really changed is the comfort of machinery and the workplace environment as it gets warmer'* (B – Operator 1). The approach remained reactive and did not allow for the implementation of proactive solutions. *'It must be said there are reactions when accidents occur. I myself will tell you, there is a lack of prevention'* (B – Operator 2). Social data confirmed employees' perceptions, specifying that the cases treated by the HSWCC over the period 2012–2014 focused exclusively on safety and workstation ergonomics. Health and safety issues delegated to this committee appear to be completely disconnected from the lean approach. Concerning health issues, working in Company B appears to have been physically fatiguing for operators (5/5) and stressful for managers (3/4). Absenteeism due to accidents at work increased substantially, from 65 in 2012 to 197 in 2014, despite the increase in budget allocated to improving working conditions. Employees perceived that efforts had been made about safety to comply with legislation, but little progress had been made on health: *'There is no overall improvement on this issue'* (B - Technician). Moreover, the lack of HIPs did not help the integration of this issue in the lean context even though *'people [have] become more involved'* (B - Human Resource Manager). The consultant's report states that they *'failed to anchor the lean and managerial routines'* and that Company B tended to *'embellish the truth when they self-assess their lean maturity level'* (Consultant B).

Company C was still at the beginning of the implementation phase five years after the decision to adopt lean. There was no vision or philosophy of lean shared among the CEO, the chief financial officer (CFO), the quality manager, the line manager, and operators. For the consultant who was working with the company, *'The real job was at the board level. It was necessary to encourage people to evolve in terms of management.'* He called on another consultant in order to bring more cohesion within the board but *'things did not function well.'* (Consultant B).

First, training and skills development remained limited, disconnected from the lean process: *'Training about lean? There isn't any'* (C - Quality Manager). Second, Company C had just begun to set up individual interviews initiated by the CFO. Third, communication and information sharing in Company C remained largely informal: billboards near the coffee machine communicated training and *'a mini corporate network that everyone can access to publish some interesting news'* (C- CEO). This network was not limited to corporate discussions but also contained current discussions. A survey on communication modalities indicated *'poor communication between departments, "top-down" and "bottom-up"'* (C- Quality Manager). A weekly planning meeting was organized but *'sometimes cancelled for three weeks'*, and *'people come without preparation'* (C - Quality Manager), making any progress difficult.

Working in Company C appears to have been fatiguing and stressful for top managers (2/3) and stressful for other respondents. Faced with these difficult working conditions, one top manager planned to change jobs. The CEO, on the other hand, considered that *'working conditions are awesome in our firm!'*, underscoring that the transition from a historical directive management to a participative one was still in progress. At the same time, the quality manager seemed less convinced: *'I don't know if it is linked with lean... Why not? lean and our own management!'* This shows that the combination of incompatible, even contradictory, practices destabilized all the company staff except the CEO. Concerning occupational health and safety indicators in the period 2012–2014, while Company C reported no accidents at work or occupational diseases, absenteeism due to illness increased from 18 days in 2013 to

26 in 2014. Expenditure for improving working conditions and preventing risks in terms of health and safety was not disclosed.

Routinization Phase

Only *Company A* really reached the phase of routinization. While the continuous improvement approach took years to be implemented and generalized, at the time of the interviews, the lean maturity diagnosis showed that 23 of 32 lean practices had been implemented, and a majority of them (17) were handled methodically, effectively and systematically. *'It took three, four years to initiate an approach that has begun to come to life and be appropriated by employees.'* (A – Industrial Director). Lean practices are integrated into all tasks and missions and are part of the company's everyday language and routines. *'Today, Atlas is in everything in A and used lavishly in our work and in speeches.'* (A – Operator 3). Furthermore, while lean philosophy was based on instrumental and productive foundations, it has evolved towards managerial ones, including health and safety management. *'At the beginning of the whole process, we had some steps that were a little sketchy, badly prepared, badly supported, that led to semblances of things, to failures, and which destabilized employees. It was necessary to go through this methodological axis, which was a little painful for people. Today, I think that we have gained in maturity. We are piloting a process of continuous improvement, while keeping a methodological base that is part of our knowhow. We have incorporated new pillars centered on wellbeing through lean practices and health and safety.'* (A – Industrial Director). *'Atlas, for me, I would say is about improving a process, in the sense of quality, safety, and productivity.'* (A – Operator 2). Unfortunately, the results for health issues are not so clear, but interviewees provide further evidence of significant improvements in working conditions. The majority of the respondents (5/8) stated that they are more satisfied today with working conditions. However, the respondents noted that the lean approach increases requirements and challenges, which can be a source of stress because many indicators are closely watched. *'What can be scary is the number of pillars and the number of indicators you have to manage. [...] it has caused, and I am sure it still causes, situations of stress for people who are piloting pillars'* (A – Industrial Director). Regarding worker health indicators over a three-year period, the expenditure for improving working conditions and preventing risks in terms of health and safety has indeed increased by 177% during the period between 2012 and 2014. The number of occupational illnesses has in fact decreased by 32 % between 2012 and 2014. However, the number of days lost due to accidents at work and the number of days absent due to illness increased by 49% and 17%, respectively, in the same period.

DISCUSSION AND CONCLUSION

This study extends the conceptualization of lean as a system composed of highly integrated elements (Shah, Ward, 2007). A novel contribution of this study is that HRM practices (from the perspective of HIPs), when taken in combination with lean practices, can moderate their damaging effect on worker health and safety along the different phases of the adoption process (*i.e.* decision, implementation, routinization). The study follows Jasti and Kodali's (2015) recommendations that *'researchers should propose various frameworks along with implementation steps to adapt the particular framework in organizations'* (p.880).

This study reveals several ways in which lean effects on health might be mitigated, depending on how the firm integrates its HIPs and lean practices along the adoption process. This link between bundles of lean, HRM practices, and worker outcomes, has been poorly investigated.

Using a full list of HIPs and lean practices, consideration of lean philosophy as well as lean maturity (both in terms of practices and adoption phases), the results confirm that the relationship between lean and worker outcomes depends on firms' ability to combine bundles of technical and managerial practices (Longoni *et al.*, 2013; Treville, Antonakis, 2006). This study extends Longoni *et al.*'s (2013) statement that '*the adoption of lean without the human component is not only mean, it is bad for operational outcomes as well*' (p. 3314). However, the current study's findings significantly nuance this. Lean is not a simple, one-way process. Lean is a 'double-edged sword' (Adler, Landsbergis, 1988), which depends on how HIPs are combined with lean practices, the phase of their adoption, and the way of thinking lean. Depending on these elements, lean can degrade or improve health outcomes.

Revisiting the relationship between lean, HRM practices and worker health in light of the adoption process: the role of bundles of practices

In the cases studied, the issue of the effects of lean on employees' health was deferred until the end of the implementation phase. It was common for the human side to be forgotten during the first steps of the implementation process. Furthermore, the decision to adopt lean was always justified by operational performance without considering the lean philosophy and its compatibility with the Taylorian culture that was already rooted. Consequently, in the first steps of implementation, lean was put into use by opening a toolbox without giving much thought to its compatibility with a company's culture or technical systems.

The adoption process appears to be mainly top-down, driven by a desire to implement lean methodology and tools learned from external consultants, which can be difficult for managers to master due to temporal and material constraints. At this stage, executives did not perceive the difficulties managers and employees faced. Lean without the support of HIPs appears to be a difficult process to implement, with a negative effect on employee wellbeing. This confirms that lean is primarily a management philosophy, which requires the involvement of everyone (Moyano-Fuentes, Sacristán-Díaz, 2012; Womack, Jones, 1994). Lean adoption entails significant organizational change; therefore, organizations should manage people at the beginning of the process (Treville, Antonakis, 2006).

Realizing the need to connect philosophy, HIPs and lean practices often occurs after a long delay. Mamman (2009) explains that lean philosophy interpretations are diverse: some are poorly developed, oversimplified, or inherently contrary to lean principles. The companies that succeed in reaching the routinization phase have faced difficulties and are often humbler about their lean expertise. They have integrated HIPs in the lean system, and specific indicators about worker health complement the previous menu of lean indicators more oriented on wasps, productivity gains, reject rate, and so on. At this stage, lean becomes more of an integrated system with both technical and HIPs, including preventive health practices. In this study, we are sufficiently removed from the beginning of the adoption process (2012) to be able to observe its effects on worker health. We consider that changes in work processes resulting from the implementation of lean can lead to improved performance within 6–18 months. In the light of social data collected in 2015, three years later results look encouraging, but they are not yet entirely satisfactory. The adoption process is not yet complete and continued efforts will be needed to reduce the number of days lost due to work accidents and occupational illnesses.

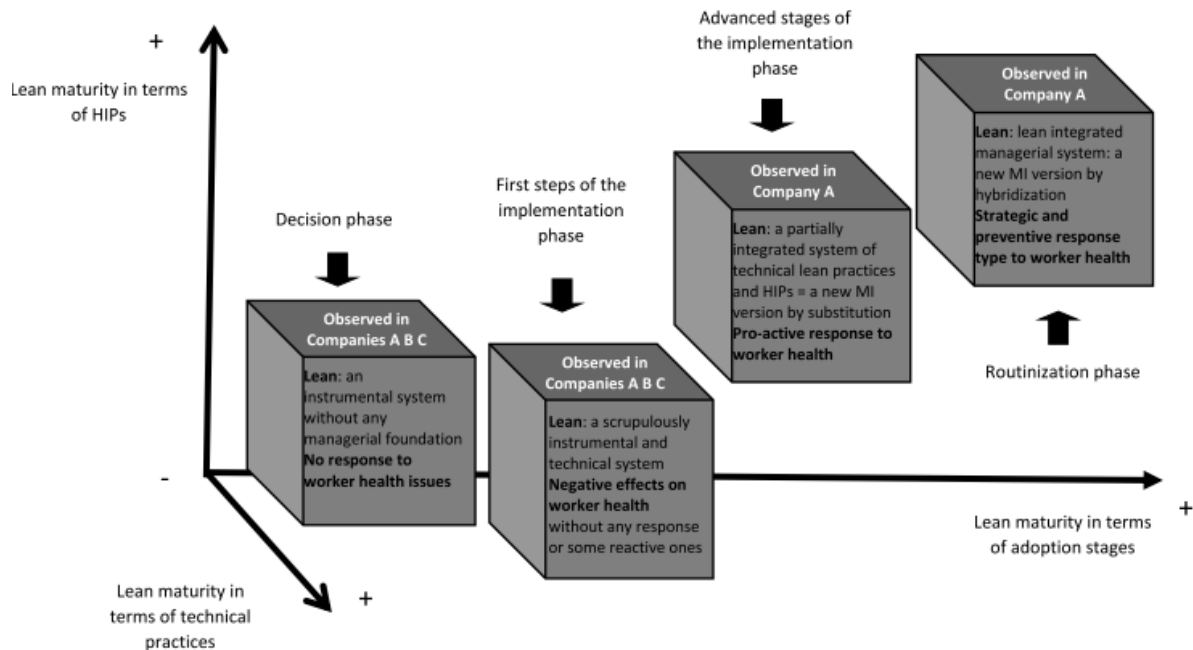
Lean as a managerial innovation: a more fine-grained assessment of organization-level practices related to adoption and adaptation

The findings also nuance the lean adoption framework stemming from the rational perspective of MI adoption, implying a simple sequence of rational activities that occur relatively automatically. Rather, it involves a complex, systemic, long process, with uncertain phases (Damanpour, Gopalakrishnan, 2001; Gondo, Amis, 2013; Hamel, 2006; Walker, Chen, Aravind, 2015; Zbaracki, 1998). In line with the cultural perspective of MI adoption (Ansari, Reinecke, Spaan, 2014; Birkinshaw *et al.*, 2008; Zbaracki, 1998), our results show that lean as an MI cannot be implemented and routinized without adaptation. We contribute to this perspective showing the crucial role that HIPs can play for this adaptation at the different stages of the process. We showed contrasting situations in terms of HIPs throughout the adoption process. In Company B, they were mainly informal and gave rise to misunderstandings or frustration when some employees were insufficiently recognized and rewarded. This lack of practices oriented toward employees' participation and empowerment hindered the firm from fully appropriating lean practices. Employees' responsibility remained limited when they faced difficulties. Thus, the solution to each problem depends on top managers' reaction, the only ones in a position to answer. This reactive approach is also observed for the health issues delegated to the HSWCC. By contrast, Company A has become so aware of the risks of an instrumental adoption of lean (because it has experienced considerable obstacles in the initial, and too theoretical, steps of lean implementation), specifically in terms of health, that health issues were used to upgrade existing lean routines with a proactive approach, seeking to transform constraints into opportunities. Participative practices, formal communication, and a dynamic training program on the lean approach and on health allow all actors involved to better appropriate lean.

In line with Mamman (2009), our results show the importance of considering MI modification that refers to '*changes made to the innovation itself so that it can fit the organizational settings*' (p.27). For this author, there does not exist a unique type of MI alteration. Some elements can be omitted (*i.e.* omission) or added (*i.e.* addition) from the 3Ps of the MI 'to make it workable or to meet the organizational or individual goals for adopting the idea in the first place' (p.41). These two forms of alteration echo what we call a defensive approach, which is observed in the first stages of the lean adoption process. Worker health issues remain largely exogenous and some solutions are proposed in responses to shocks such as injuries, diseases etc. By contrast, some elements of the 3Ps can be replaced by 'new elements' (*i.e.* substitution) or mixed with elements of 3Ps of another MI (*i.e.* hybridization) in order to achieve specific objectives. In the light of our results, these types of alteration are a sign of a more proactive and mature approach that allows employees to become agents of change. Following Souza and Alves (2018), our results also show that the transition from a technical and instrumental version of lean to a lean integrated socio-technical system requires the passing of difficult steps that can have negative effects on worker health. Organizations face difficulties in operating multiple managerial systems simultaneously to achieve an integrated managerial innovation, which will better respect worker health and render organizations more sustainable (Barisi, 2011).

In summary, such an approach of lean adaptation shows the relationship between lean, HIPs, and health in a new light that can reconcile previous contradictory results (see *Figure 1*).

Figure 1 - The relationship between lean, HIPs and worker health along the adoption process



Contributions, limitations and research avenues

In addition to proposing a method to evaluate firms' lean maturity, this study offers two new main insights for a better understanding of the relationship between lean and worker health. First, previous studies on the effects of lean on health explain the instability of results by the incomplete or inadequate way of operationalizing lean (Longoni *et al.*, 2013; Parker, 2003). In particular, a critical issue emerged concerning the non-inclusion of the multi-dimensional nature of lean (Longoni *et al.*, 2013). We go beyond this critique by proposing a three-dimensional identification of lean maturity: (1) maturity in terms of the technical lean practices adopted by the firm according to its level of expertise; (2) maturity in terms of phases of adoption (decision, first step of implementation, implementation and routinizing); (3) maturity in terms of HIPs and the way they are integrated into the lean system. Considering these dimensions, the very nature of lean becomes clear, as well as the differentiated responses to operational health throughout the adoption process (see *Figure 1*). Up to now, HIPs have rarely been considered as a valuable dimension of lean. Some previous studies have shown their moderator role in the relationship between lean and occupational health (Bruère, 2014; Longoni *et al.*, 2013). Our results indicate something similar, with one important difference. It is not sufficient to adopt HIPs concomitantly with technical lean practices if they are not fully integrated into the lean system and if they are limited to a few disconnected human practices. As observed in Company A, continuous improvement practices and health preventive human practices must be combined with common lean indicators. Following some rare authors (Combs, Liu, Hall, Ketchen, 2006; Macky, Boxall, 2007; Wood, De Menezes, 2008), this suggests, beyond the traditional HIPs identified in the literature, the need to consider prevention practices as an important bundle of HIPs. In that sense, workers' health does not mean 'more of everything' but depends on their combination in the same 'lean system'. Here we extend previous results on the crucial role of configurations (Cua *et al.*, 2001) or bundles of practices (MacDuffie, 1995) by expanding the

range of both socially- and technically-oriented practices and by establishing their link with worker health. Furthermore, our results show the crucial explanatory role of adoption phases on this relationship.

Second, this research also contributes to a better understanding of the link between MI adoption and social performance, which is still understudied (Damanpour, 2014). First, results emphasise the complexity and non-linear nature of this link. Workers' health needs the lean process to be adapted, allowing the latitude to employees to make these issues become theirs, but this takes time. We here propose to extend Mamman's typologies of MI modification by considering the different phases of lean adoption.

Third, this study has important managerial contributions. First, the research points to the necessity for top managers to make a diagnostic of their lean maturity, including their HIPs. Except for one firm that reached the most advanced phase, top managers tended to overestimate their degree of maturity in terms of lean practices and adoption phases. Similarly, the managerial practices they declared as effective in their organization are non-existent in reality. Reducing this discrepancy between discourse and reality is of primary importance. Too often, firms perceive lean first from a technical point of view while ignoring its potential negative effects on health. Both top managers and consultants should be aware of the crucial role of HIPs in adapting lean to organizational culture and anticipate employees and managers' tensions and stress throughout the adoption process. This requires not only the mobilization of new HIPs, but their effective integration into the lean system. Results also provide a recommendation for consultants in charge of accompanying firms in a lean approach: they should rethink their role, which is too often limited to the adoption of technical practices. Important preliminary work must be carried out on the managerial philosophy and 'how' lean can be adopted. Similarly, consultants facilitating the adoption of a lean source of operational performance should not overlook social performance. Considering this type of performance should be at the heart of their program and mission.

Finally, this study is not exempt from limitations, which also represent future research opportunities. First, the research is based on three case studies of French industrial companies that have adopted the same regional lean program during their adoption process. A larger sample that includes both companies that used external consultants and those that did not would improve its external validity. Second, this study is based on a cross-sectional design, which does not allow for closely tracking social data throughout the process. Incorporating a longitudinal design could help capture changes in practices and their effects on worker health. Third, the study is focused on internal actors; however, external stakeholders might, for example, favor the diffusion of sustainable practices. Thus, studies could be undertaken to identify the role of stakeholders in the supply chain. Fourth, a growing body of literature addresses the environmental dimension of lean practices, which results in the new concept of 'green lean'; however, the social aspects of this dimension remain largely unknown (Barisi, 2011). Further work is needed to investigate lean social performance and its antecedents. In particular, although our data show that the lean adoption process is linked to managerial practices related to the liberated company (Getz, 2009), such as flexible working conditions, greater autonomous worker decisions, a self-managed team and more direct communication practices (see Pierrard-Mattelin, 2019 for a review on such practices), hierarchical control and formalization are still very present. Future research could examine whether the liberated company may be a possible extension of lean management and if so, under what conditions.

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Appendix A- Companies' Health and Safety Indicators

Health and Safety Indicators (objective measures)

Company	Total number of departures (rate of employee turnover)				Occupational illnesses				Absenteeism due to illness in days				Days lost due to work accidents				Continuing education expenditure (%)				Expenditure to improve working condition (k€)			
	2014	2013	2012	Var. (%)	2014	2013	2012	Var. (%)	2014	2013	2012	Var. (%)	2014	2013	2012	Var. (%)	2014	2013	2012	Var. (%)	2014	2013	2012	Var. (%)
A	89 (5.4)	69 (4.1)	72 (4.2)	24	17	21	25	-32	14656	14768	1251 6	17	1337	1007	898	49	2.88	2.8	2	1	5688	4425	2050	177
B	2 (3.8)	4 (3.8)	1 (3.9)	100	0	0	1	-100	919	1242	1267	-27	197	136	65	203	1	1	1	0	250	210	150	67
C	1 (4.3)	3 (11.5)	NC*	-67	0	0		0	26	18	NC	44	0	0	NC	0	NC	NC	NC	NC	NC	NC	NC	NC

*NC= Not communicated