Prevention Pathways: Application of the Critical Path Methodology in Occupational Health Services

Lode Godderis, MD
Kris Vanhaecht, RN, MSc
Raphaël Masschelein, MD, PhD
Walter Sermeus, RN, MSc, PhD
Hendrik Veulemans, PhD

Occupational health services face important changes as a result of changes in work environment, changing health and safety concepts, and legislation. To ensure good quality at a good price, it is important to control the processes in occupational health services. The concept of "prevention pathways" is presented for the management of occupational health services. The model is based on the critical pathway concept. The approach is illustrated by means of a case study performed in a Belgian occupational health service. A prevention pathway for the evaluation of chemical risks at the workplace was constructed. The prevention pathway methodology revealed inefficiencies and quality problems in the current practice of chemical risk assessment and biomonitoring. The case shows how prevention pathways can be used to pilot the members of a multidisciplinary team by focusing on a specific occupational risk. (J Occup Environ Med. *2004;46:39–47*)

Occupational health services (OHSs) are facing important changes in their practice. This is not only the result of rapid changes in working life and work environment, but also changing health and safety concepts, attitudes, and legislation.[1,2] The European Union's Framework Directive 89/391/EEC on "The Introduction of Measures to Encourage Improvements in the Safety and Health of Workers at Work" introduced new approaches in European occupational prevention.[3] The emphasis of this directive is more on primary prevention, ie, preventive measures that reduce all occupational risks.[4] Simultaneously with this shift in attitude from secondary (and tertiary) prevention toward primary prevention, the concept of multidisciplinarity has been adopted in the OHSs and legislation.[5]

Historically, Belgian OHSs have been mainly focused on medical and safety aspects. Occupational physicians and nurses worked mainly in their offices performing different types of medical examinations (preemployment examinations, periodical examinations, spontaneous consulting hours, and so on) and, to a lesser extent, they were also involved in health risk surveillance at the workplace. Safety engineers dealt mainly with the prevention of occupational accidents and other safety aspects of the company.[5–7] Thus, each of these 3 prevention advisors addressed psychosocial, ergonomic, and industrial hygiene aspects according to their knowledge and inter-

From the Laboratory of Occupational Hygiene and Toxicology, Occupational and Insurance Medicine, Katholieke Universiteit Leuven, Leuven, Belgium (Drs Godderis, Masschelein, and Veulemans); and the Center for Health Services and Nursing Research, School of Public Health, Katholieke Universiteit Leuven, Belgium (Drs Vanhaecht and Sermeus).

Address correspondence to: Lode Godderis, MD, Katholieke Universiteit Leuven, Department of Occupational and Insurance Medicine, Kapucijnenvoer 35/5, 3000 Leuven, Belgium; E-mail address: Lode.Godderis@med.kuleuven.ac.be.

DOI: 10.1097/01.jom.0000106011.10612.96

est. However, as a result of an increasing demand and complexity in those fields, other experts have gradually become involved. These include a specialist in psychosocial problems, ergonomists, and hygienists.

This evolution has led to a growing specialization in the field of occupational health and prevention. Safety engineers still focus their efforts on safety and accident prevention. Physicians and nurses keep their medical roles (occupational medicine). Industrial hygienists primarily perform assessments of exposures to chemical, physical, and biologic agents.[8,9] Ergonomists study the design for human use and the optimization of human performance at work and in adverse environments.[8,10] Industrial psychologists play an important role in exploring relationships between work and mental well-being.[11]

It is clear that occupational health and safety are no longer responsibilities of the occupational physician, nurse, and the safety engineer alone. A whole team of experts is now available with one common goal: assuring the well-being of the workers. Ideally, all disciplines should work together to obtain the best result. Increased specialization might lead to a better knowledge and experience of the discipline and consequently to better analyses and advice. However, increased specialization also caries certain risks. The involvement of many specialists results in growing costs, and delays in the implementation and fragmentation of the preventive service. To ensure good quality at a reasonable price, appropriate organization and evidence-based guidelines have to be developed in the field of occupational medicine and prevention at work in general.[7,12]

We present "prevention pathways" (PPs) for a process management of OHSs. The model is based on the experience with and knowledge of the critical pathway concept that operates in the industry[13,14] and the clinical pathway concept that has been developed in hospitals.[15,16] First, we describe the development and important theoretical aspects of the methodology. Then we illustrate the approach by means of a case that was worked out in a Belgian OHS. The outcome is a proposal for a PP concerning chemical risks in a medium-sized plant.

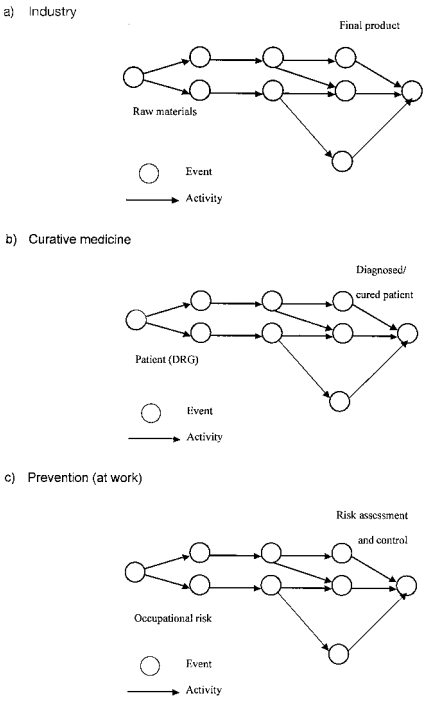

Fig. 1. Schematic overview of the processes in industry, curative medicine, and prevention at work (occupational medicine).

History, Concept, and Definition of Critical and Clinical Pathways

Originally, the concept of critical pathways was developed in industry and was called critical path method (CPM) or program evaluation and review technique (PERT).[13] Both terms refer basically to the same concept. In brief, the critical path method breaks down a project or process into separate identifiable jobs. Figure 1 gives examples of processes in industry, curative medicine (hospitals) and prevention at work. Activities are represented graphically by arrows. The start and finish of an activity are represented by circles and are referred to as events or nodes. In industry, raw materials follow a certain route of activities through machines and processes to result in a final product (Fig. 1A). The critical path method focuses on the critical activities and tries to increase their efficiency. These critical activities are activities, which, if delayed, cause a similar delay in the total project or process. Therefore, they require special attention to complete the project or process on time. CPM and PERT are, nowadays, used in industry as continuous quality improvement methods or project management systems.[13]

Around 1985, a team in the New England Medical Centre in Boston modified and adopted the CPM technique in health care. They called it case management plans and later clinical pathways.[16] A clinical pathway is defined as a collection of methods and tools to guide the members of a multidisciplinary and interdisciplinary team toward patient-focused collaboration for a specific patient population.[15] Clinical pathways break down the caring process into different activities (diagnostics, medical treatments, and so on, often per diagnosis-related group (DRG), and define the different tasks of the different team members. The activities are concentrated on the treatment of patients or groups of patients (DRG) and are executed by different work units and specialists. At the end of the pathway, the result is a diagnosis of a disease or a cured patient (Fig. 1B). The goal of the concept is to ensure high-quality and efficient care. Clinical pathways allow systematic planning and follow up of a patient-focused care program.[15] Initially, the pathways were used for the management of nursing care.[17] The use of clinical pathways has been extended to the whole of curative care in basically every discipline of medicine.

In the curative sector, the pathway is mostly represented as a time–task matrix (see further). The most com-

mon term is "clinical pathway,"[18,19] although several synonyms can be found: care pathway,[20–22] care track,[18] Caremap,[16,23] anticipated recovery paths,[24] managed care plans,[20] collaborative pathways,[20] care plan,[17] critical pathway,[20,25,26] multidisciplinary care protocol,[27] and integrated care pathways.[19,22]

The Concept of Prevention Pathways

Reasoning by analogy with the clinical situation, we applied the CPM concept in the OHSs. The applicability of the approach in OHSs depends on the existence of processes that can be broken down into a series of activities that follow a logical and predictable sequence. As indicated previously, in the curative sector, clinical pathways describe processes according to diseases (often DRG), clinical conditions or problems. In OHS, one could also consider occupational- and work-related disorders (eg, based on the European list of occupational diseases), occupational accidents, and health complaints as bases for developing pathways.

However, it seems more appropriate to consider occupational risks (ri). Figure 1C shows an example of a process in an OHS according to this approach. A pathway could be developed per type of occupational risk. The different specialists carry out a number of activities to assess and control occupational risks to reduce occupational risks and prevent occupational diseases (Fig. 1C). The pathway per type of occupational risk shows the preventive activities that take place at the levels of both worker and workplace. It shows the process through the different disciplines involved. This means that the medical and nonmedical activities at worker and workplace level, and consequently the disciplines involved, are determined by the occupational risk under consideration.

Describing the process according to occupational risk offers another advantage, because this emphasizes primary prevention more adequately without losing sight of secondary and tertiary prevention. Three levels of detail for PP development can be distinguished:

- According to risk group, eg, chemical risk, physical risks, etc.
- According to chemical group, eg, polyaromatic hydrocarbons, ionizing radiation, etc.
- According to product, eg, benz[a] pyrene, x-ray.

The level of detail depends on the time and ultimate goals of the OHS for PP implementation.

Because the CPM concept needs some modifications for application in occupational health, we introduce the term "prevention pathways (PP)." Thus, PPs are defined as a collection of methods and tools to pilot the members of a multidisciplinary and interprofessional team dealing with a specific occupational risk. PPs are a means of identifying and defining the different tasks of various team members.

PPs can be seen as clinical pathways developed in and for prevention at work. However, the term clinical pathway cannot be used in this field because of some important differences between curative medicine and OHS. In OHS, one mainly deals with healthy workers to keep them healthy, whereas in curative medicine, patients are treated to cure them and improve their health condition. Although part of the activities in prevention at work are also clinical and worker-related (medical examinations, vaccinations, biomonitoring, and so on), there is an important part of the preventive activities that are executed at the workplace, which is not clinical or medical (eg, ambient exposure measurements, risk analysis, and so on). Therefore, the term clinical pathways is better not applied in this context because it would put too much emphasis on the medical aspects of prevention.

The main reasons for developing pathways in OHSs actually do not differ from those in the curative sector.[28] Like in curative medicine, PPs can be a useful tool: to streamline processes, to enhance multidisciplinary teamwork, to maintain or improve quality of service, to reduce costs, to implement best practice guidelines (evidence-based), to facilitate outcome orientation, to support active risk management and to track variances, to link guidelines and available resources, and so on.[11,12,13,15,19,21,29–32] The aim of the PP is to improve prevention at work, which consequently should result in a better health condition of the worker and a healthier and safer work environment. PPs can then be used to organize the process of occupational risk assessment and occupational risk control through a series of activities (measurements, analyses, and so on) performed by the different members of a multidisciplinary team. Just like for clinical pathways, the time–task matrix can be used to represent PPs. The time–task matrix shows the logical sequence of activities placed along a time axis (Table 2).

Case Study

Introduction

To evaluate the applicability of the PP methodology, a case study was designed in a Belgian OHS. The case considered the development of a PP for chemical risk assessment by a Belgian OHS. In Belgium, OHSs are called "External Services for Prevention and Protection at Work" (ESPPW). All firms employing people are obliged to provide occupational prevention. Firms can organize an internal service; however, most firms have completely or partly (eg, occupational health surveillance) outsourced this activity to an ESPPW. The Belgian legislation (3 Royal Decrees and the Law on Well-Being of Workers) defines the practice of prevention at work in Belgium.[33–36] This legislation determines the qualities and the competencies required for the service to be recognized as an

official ESPPW. In 2001, there were 24 official ESPPWs in Belgium.

The ESPPWs are divided (by Belgian law) into 2 different units: a unit of occupational health surveillance (occupational medicine) and a unit of risk assessment and control.[35] The unit of occupational health surveillance consists mainly of physicians and nurses. The unit of risk assessment and control can also include physicians and nurses, but it mainly includes safety engineers, ergonomists, hygienists, and experts in psychosocial aspects. The ESPPW works together with external organizations for some activities, eg, the laboratory, for the analysis of samples of biomonitoring. Because prevention is done in and with their clients (the firms), ESPPW specialists (eg, physicians) work together with prevention specialists of the client (eg, safety engineers of the firm).

Contracts drafted by firms with ESPPWs are still mainly focused on occupational medicine. An occupational physician and occupational nurse are in charge of the health surveillance of the workers. They also carry out other preventive activities (eg, visits to the workplace, and so on). The other professionals of the ESPPW come in contact with the client mainly through additional contracts (eg, chemical risk assessment) or through support given to the occupational physician.

In this case, we tested and implemented the PP methodology in an ESPPW to deal with chemical risk in medium-sized firms. The aim was to evaluate the applicability and the value of the PP theory for the management of preventive care delivered by an ESPPW in a firm. The case study was mainly focused on the process, the determination of actors of the activities, and the time aspects per activity.

Methods

The case study took place in a Belgian ESPPW between February 2002 and June 2002. A variety of methods to develop and implement a critical and a clinical pathway can be found in the literature.[13,15,28,37–45] Like in curative medicine, it was important to involve the multidisciplinary team in the development, implementation, and evaluation of the pathways. The degree to which a multidisciplinary team is involved in the development, implementation, and evaluation depends on the use of the Plan–Do–Check–Act cycle (PDCA cycle) (Fig. 2).[15,46] The PDCA cycle, with some slight modifications, was applied for the development of PP concerning chemical risk assessment. De PDCA-cycle is divided into 4 phases.

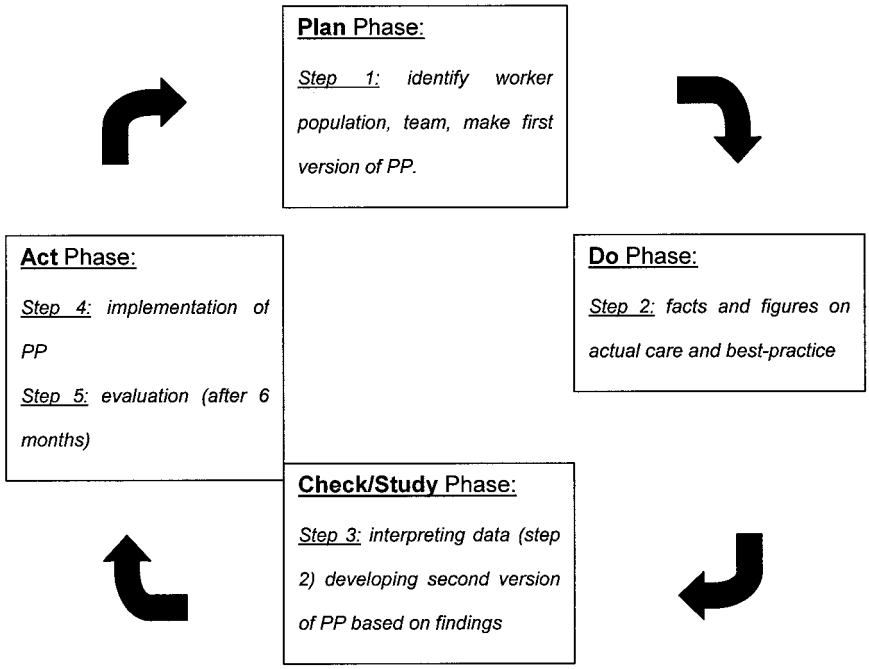

Fig. 2. Prevention Pathway development: Plan–Do–Check–Act cycle.[15]

Plan Phase. The plan phase started with defining the problem (ie, chemical risk assessment). The starting point chosen for the pathway considered here is the first contact between the ESPPW and a firm for performing chemical risk assessment. The ending point of the pathway is the final report of the assessment and follow-up plan. The size of the firms is medium-sized firms with 50 to 200 employed workers. Because PPs are essentially a team approach, a multidisciplinary team was first composed. A representative was selected from each of the following disciplines: occupational physicians, nurses, hygienists, ergonomists, psychologists, and safety engineers. Every representative had experience in his field. All activities were listed and put into a first time–task matrix by means of brainstorming.

During the Do phase, information on current practice and evidence-based practice was gathered. This was done through analysis of historic data and a search of the scientific literature. The historic data analysis included risk assessments (n = 10 projects), exposure assessments (n = 12 projects), and biologic monitoring data (n = 30 individuals). The historic data analysis was done in a regional office of the ESPPW, and only assessments and biomonitoring of the last 2 years were considered. The activities, time, dates, and results were listed in a time–task matrix. The literature and legislation search gave additional information on the activities (eg, which activity must be done according to the law and which activities can be used to reach the expected result).

The Check/Study Phase. The data from the Do phase were interpreted

and, based on the findings of the Do phase, the first version of the PP (time–task matrix) was adjusted. The team concentrated further on the most essential (read critical) elements of the approach. Every step was considered with the focus on the result. A complete capacity and means was worked out. All necessary application forms (eg, for laboratory tests, measurements, and so on) were collected and responsibilities were determined. A plan for the collection of data in the "Act phase" was prepared as well in this phase.

The Act phase is the phase in which the final version of the pathway is implemented. The time–task matrix is currently used to guide the actors through the process. The actors use the time–task matrix to report the difficulties and objections they meet. This information, together with an update of best practice literature, is then used for a continuous improvement of the approach. This evaluation occurs periodically after a fixed period (every 6 months).

Results

Figures 3–5 are time–task matrices showing the PP for chemical risk assessment. The time aspects (in days) described are the result of the historic data analysis. The day number of the time–task matrix refers to the median number of days between start (on day 1) and date at which the activity was actually performed. The matrix describes the activities and mentions which discipline is responsible for the execution of the activity (eg, collection of sample, codification, and so on). The total PP for chemical risk assessment is divided into 3 main parts: initial appraisal and basic survey, detailed survey, and medical follow up with biomonitoring. Every part starts with a contract-negotiating phase between the ESPPW and client, then the contract is executed, and finally the invoice is sent to the client and payment follows.

Figure 3(a) shows the activities involved in the negotiation of the initial appraisal-basic survey contract. Contracts (n = 10) were drafted in half days. The size of the contracts ranged between 3 and 12 half days. The negotiation of the contract took a median of 44 days (range, 23–77 days). Figure 3(b) shows the execution of the contract (n = 10). The initial appraisal and basic survey include an inventory of all chemical agents, a visit, and screening of the workplace. This results in a consideration of the likelihood of the exposure (initial appraisal) and/or a quantification of the exposure (basic survey). Part 1, considering the period between the first meeting with the client and the handing over of the report, lasted a median 308 days (range, 103–436 days). Of these 308 days, 264 days were necessary (range, 80–359 days) for the execution of the contract.

Part 3 is the detailed survey where measurements in air were performed to obtain validated and reliable information of the exposure (n = 12). There was a median of 15 days (range, 7–83 days) between the start of the measurement and the sending of the report to the client by mail (Figure 4).

Part 4 describes the medical evaluation, including biomonitoring, of the individual employees exposed (n = 30). Figure 5 shows the process of biomonitoring. The whole process between medical examination with

Time	Day 1[a]		Day 4,5[a]		Day 7[a]		Day 28[a]		Day 44[a]	
	Range (days)[b]	Executed by	Range (days)[b]	Executed by	Range (days)[b]	Executed by	Range (days)[b]	Executed by	Range (days)[b]	Executed by
			1-11		1-11		11-77		23-77	
Activity	Meeting between client and ESPPW	Safety engineer	Internal communication and supervision by department responsible of the contract proposal	Safety engineer and department responsible	Sending the contract to the client	Safety engineer and postal service	Signing the contract by client	Client	Receipt of signed contract	Safety engineer
	Visit of the workplace	Safety engineer					Sending the signed contract to the ESPPW	Client and postal service[c]		
	Making of a contract proposal	Safety engineer								

(a)

[a] Median number of days between start (day 1 and execution of activity (historic data)

[b] Range (days): gives the range of number of days since start (day 1) per activity or per group activities

Time	Day 55,5[a]		Day 185[a]		Day 287[a]		Day308[a]	
	Range (days)[b]	Executed by	Range (days)[b]	Executed by	Range (days)[b]	Executed by	Range (days)[b]	Executed by
	11-118		80-428		103-435		103-436	
Activity	Start initial appraisal and basic survey	Safety engineer	Consult between occupational physician and safety engineer	Physician and safety engineer	Making of report	Safety engineer	Handing over the report and explanation to the client	Safety engineer

(b)

[a] Median number of days between start (day 1 and execution of activity (historic data)

[b] Range (days): gives the range of number of days since start (day 1) per activity or per group activities

Fig. 3. (a) Example of a Prevention Pathway part 1a: negotiating the contract for chemical risk assessment. (b) Example of a Prevention Pathway part 1b: the initial appraisal and basic survey.

Time	Day 1[a]		Day 2[a]		Day 3[a]		Day 5.5[a]		Day15[a]	
	Range (days)[b]	Executed by	Range (days)[b]	Executed by	Range (days)[b]	Executed by	Range (days)[b]	Executed by	Range (days)[b]	Executed by
			1-6		1-8		2-16		7-83	
Activity	Start measurement	Hygienist	Receipt of samples in laboratory	Lab technician[c]	Analysis of the samples by GC-MS	Lab technician[c]	Making of analysis report	Lab technician[c]	Receipt of report	Hygienist
	Sending samples	Hygienist and postal service[c]					Supervision of report Mail report to ESPPW	Lab responsible[c] Lab technician and postal service[c]	Making of report Sending of report to client	Hygienist Hygienist and postal service[c]

[a] Median number of days between start (day 1 and execution of activity (historic data)

[b] Range (days): gives the range of number of days since start (day 1) per activity or per group activities

[c] Executed outside the ESPPW

Fig. 4. Example of a Prevention Pathway part 2: detailed survey.

Time	Day 1[a]		Day 4[a]		Day 8[a]		Day 21[a]		Day 29[a]	
	Range (days)[b]	Executed by	Range (days)[b]	Executed by	Range (days)[b]	Executed by	Range (days)[b]	Executed by	Range (days)[b]	Executed by
			1-6		6-36		12-57		19-63	
Activity	Medical pre-examination of employees	Nurse	Delivery of urine samples at regional office	Nurse	Transport of urine samples	Pick-up service	Analysis of urine samples	Lab technician[c]	Mail report to ESPPW	Lab technician and postal service[c]
	Collection urine sample of employees	Nurse			Reception of samples by laboratory	Lab assistant[c]	Making of analysis report	Lab technician[c]	Receipt of report	Administrative employee
	Medical examination of employees	Physician					Supervision of report	Lab responsible[c]	Codification of results	Administrative employee

[a] Median number of days between start (day 1 and execution of activity (historic data)

[b] Range (days): gives the range of number of days since start (day 1) per activity or per group activities

[c] Executed outside the ESPPW

Fig. 5. Example of a Prevention Pathway part 3: time task matrix for medical follow-up and biomonitoring.

collection of urine sample and availability of the results took a median of 29 days (range, 19–63 days). After 8 days (range, 6–36 days), the samples arrived at the laboratory for further analysis. During this process, there is, on the one hand, a transport phase lasting median 18 days (range, 11–42 days) and, on the other hand, an analysis phase in the laboratory with a median duration of 14 days (range, 4–35 days).

Discussion

The study case shows that the PP methodology can be applied in OHSs (ESPPWs) as a diagnostic tool to determine critical points in a preventive approach. The process of chemical risk assessment and follow up could be described. Chemical risk assessment in ESPPW is a process that follows a predictable series of activities[47–49] This confirms the hypotheses that processes describing the service can be detected in OHSs. Describing the process from the point of view of occupational risk gives the advantage that activities reducing the risks at work (primary prevention) are placed together with other activities (secondary and tertiary prevention). This makes an integral prevention visible and possible. All activities for chemical risk assessment executed by the ESPPW could be placed into a logic (time) order and presented in a time–task matrix. The presentation of the activities in a time–task matrix allowed discussion about the responsible discipline for each activity. Agreements of responsibilities were made between the team members. Those agreements make coordination possible between the different units involved.

The approach is based on the European Directive EN 689.[50] The assessment of chemical risks is a complex process in which different experts of the ESPPW and firm play a role. The approach is mainly performed by 3 disciplines: safety engineers, occupational hygienists, and occupational physicians. Safety engineers are responsible for the contract negotiation, the initial appraisal, and basic survey. During the initial appraisal, the safety engineer does not only collect data necessary for the evaluation of safety aspects (eg, risk of explosions), but also general data (eg, inventarization of chemical agents, workplace factors), which are necessary for evaluation of health risks (risk of poisoning, reproductive effects, or chronic health problems such as cancer, allergy, and so on). Before making the report of this phase, the safety engineers and occupational physicians meet for an evaluation of the data. During the detailed survey, most activities are executed by occupational hygienists. This phase includes measurements of exposure at the workplace, which require specific skills and equipment. The approach ends with medical examination and biomonitoring. This includes an important consideration of person-related factors in the risk assessment. Occupational physicians are trained for assessing those aspects.

Ergonomists and experts in psychosocial aspects have a less obvious role, and the team decided not to include them in the present approach. However, their intervention might be necessary in some circumstances. Ergonomists can assess the workplace

and give advice concerning the optimal concept of the workplace, eg, the less physical effort an operator has to do, the less the respiratory uptake of a possible agent will be. Experts in psychosocial aspects can play an important role in risk communication and in evaluating stress factors associated with working with dangerous agents. The future will clarify if input from these experts is necessary in chemical risk assessment.

A frequently heard critique and fear is that working according to a defined process or procedure is rigid and reduces flexibility. However, the PP approach is not a static but dynamic concept. The PDCA cycle allows continuous adjustment and improvement of the pathway. Employees who have not followed the approach are requested to write down their comments and followed approach. This can be written down on the time–task matrix. This information is then used during the periodic evaluation and update of the PP. The experience of the actors is necessary for and facilitates the setup of an approach taking into account the common practice and its restrictions. These periodic evaluations are also used to keep the pathway updated with best practice guidelines and evidence-based approaches.

An important step during PP development is the historic data analysis. The inclusion of an historic data analysis was necessary to have a clear view of the current practice, the time and resources that these projects consume. These data can be used to evaluate the quality, cost, and efficiency of the service delivered. Quality of the OHS includes the technical quality of the total process. Process indicators such as time between activities and logical order of examination can help to evaluate this aspect. During the development of the PP, every activity was evaluated critically: Is the activity the appropriate activity to reach the goal (evidence-based)? Which activities need to be performed before the activity can take place and which activities need to follow the activity, ie, a critical look at the logical order to reach the final objective? Because the strength of the approach is in the weakest link, every step was considered with the focus on the result.

Part 4 of the approach (medical follow up and biomonitoring) shows clearly how time aspects can be important for quality in OHSs. It takes a median of 8 days before urine samples arrive at the laboratory. This means that the urine samples require special storage and transport conditions to avoid evaporation of water or volatile compounds, precipitation, and adsorption. Organic compounds have a limited lifespan in biologic matrices, eg, in urine some bacteria can biotransform a variety of organic molecules.[51] Therefore, the ESPPW needs to reduce the transport time of the urine sample between collection and arrival at the laboratory or needs to provide appropriate containers to transport the samples to ensure reliable results of biomonitoring. Moreover, if the total transport time (transport time of the samples and transport time of the report) could be reduced, this would mean that results would be available sooner for the physician. Remedial actions in case of problems could then be taken earlier, which would consequently increase the result of the prevention and probably client satisfaction.

The advantage of splitting up the preventive work in activities is not only the optimal coordination and quality control of the activities, but also the fact that the cost per activity can be calculated. The costs of the whole process can be determined using a method called activity-based costing.[52,53] In brief, activity-based costing calculates the cost of a product (here preventive service process per occupational risk) by allocating all direct costs to the process. Indirect costs are allocated according to the consumption of activities in the process and the consumption of resources (costs) of each activity. Because the origin of the costs is known, the management of the OHS can take measures to increase efficiencies and to reduce costs where necessary. Activity-based costing was not formerly performed in this study.

Nevertheless, the historic data revealed a serious inefficiency in the current practice of initial appraisal and basic survey. The actual execution of the contract required a time period of median 264 days (range, 80–359 days). This seems to be a very long period, taking into account that in this study, only contracts of a maximum of 6 days were included. Through this, the OHS looses a potential of follow-up contracts and loses money because invoices are sent after termination of the contract. It has to be stressed that in OHS, the final outcome and the timespan will be a result of the good quality of the prevention, but also of the cooperation of the clients. Therefore, reasons for inefficiencies have to be searched in both the organization of the OHS and the cooperation with the client. It should be clear that for OHSs and for clients, it is important to receive the results of analyses as soon as possible to avoid accidents and occupational health damage. The process of biomonitoring also illustrates this, eg, results exceeding exposure limits require urgent measures. The results of the biomonitoring in the ESPPW were only available after 1 month. Knowing that 50% of this time is consumed by transport factors (transport of samples to laboratory and transport of results to physician), it seems useful for the ESPPW to try to reduce this “lost” transport time to a minimum.

In conclusion, we can state that the PP methodology is a promising methodology for continuous improvement of OHS services in different aspects, process and quality control, cost reduction, enhancement of multidisciplinary cooperation, and so on. At this stage, we can state that PPs are able to show critical points for quality and time management in OHS and help to attribute the tasks to the different work units and actors

involved in the process. The development and implementation of clinical pathways in curative medicine have shown positive outcomes for patients, hospitals, and healthcare workers (quality improvement, cost reduction, increased team efficiency, improved patient satisfaction, and so on).[15,17,30,54–59] Eventually, we can expect similar results in OHSs. However, the degrees to which improvements in the prevention process are made depend for a big part on the commitment of the OHS management. It is clear that further research and application is necessary to evaluate the possible application and outcomes of the PP concept. A follow up to evaluate the effect of this case study has been setup in the Belgian ESPPW. The follow up focuses mainly on time aspects and financial aspects.

Acknowledgments

The authors thank the management of the ESPPW, where this case study took place. We especially acknowledge the members of the PP team, whose input and effort were necessary for the completion of the case study. They also thank Prof. Dr. B. Nemery for the critical reading of the article.

References

1. Van der Vliet JA. Occupational health in European member states: a road to organizational health. *Int J Occup Med Environ Health*. 2001;14:13–17.
2. Indulski JA. Occupational medicine at the verge of the twenty first century: evaluation of accomplished and expected changes in the preventive approach. *Int J Occup Med Environ Health*. 1997;10:1–10.
3. European Commission. Council Directive 89/391/EEC of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work. *Official Journal of the European Commission*. 1989;183:1–8.
4. Kaplan RM. Two pathways to prevention. *Am Psychol*. 2000;55:382–396.
5. Kopias JA. Multidisciplinary model of occupational health services: medical and non-medical aspects of occupational health. *Int J Occup Med Environ Health*. 2001;14:23–28.
6. Hoet P, Lison D. The practice of occupational and environmental health in Belgium. *Int Arch Occup Environ Health*. 1996;68:137–140.
7. Georg A. Industrial medicine and the culture of health and safety at work. *Occup Med*. 1993;43:43–46.
8. Fraser TM. Ergonomics and industrial hygiene: a complementary relationship. *Am Ind Hyg Assoc J*. 1984;45:5–8.
9. Robinson ST. Role of industrial hygiene in medical surveillance. *Occup Med*. 1990;5:469–478.
10. Stubbs DA. Ergonomics and occupational medicine: future challenges. *Occup Med*. 2000;50:277–282.
11. Fingret A. Occupational mental health: a brief history. *Occup Med*. 2000;50:289–293.
12. Harris JS. Development, use, and evaluation of clinical practice guidelines. *J Occup Environ Med*. 1997;39:23–34.
13. Moder JJ, Phillips CR. *Project Management With CPM and PERT*. New York: Reinhold Publishing Corp; 1964.
14. Lang D. *Critical Path Analysis: Techniques, Exercises and Problems*. New York: Dover Publications; 1970:1–22.
15. Vanhaecht K, Sermeus W, Vleugels A, et al. Development and use of clinical pathways in healthcare [Dutch]. *Tijdschrift voor Geneeskunde*. 58:1542–1552.
16. Zander K, Etheredge ML, Bower KA. *Nursing Case Management: Blueprints for Transformation*. Boston, Massachusetts: New England Medical Center Hospitals; 1987.
17. Chang PL, Wang TM, Huang ST, et al. Effects of implementation of 18 clinical pathways on costs and quality of care among patients undergoing urological surgery. *J Urol*. 1999;161:1858–1862.
18. Sermeus W. Clinical pathways in nursing practice [Dutch]. In: Van Beek CC, Van Dorsten TC, Boekholdt MG, eds. *Handboek Verpleegkundige Innovatie*. Houten/Diegem: Bohn Stafleu Van Loghum; 1996.
19. Tahan HA, Cesta TG. Evaluating the effectiveness of case management plans. *J Nurs Adm*. 1995;25:58–63.
20. Layton A, Moss F, Morgan G. Mapping out the patient's journey: experiences of developing pathways of care. *Qual Health Care*. 1998;7:30–36.
21. Smith P. Nurse and physician perspectives on clinical pathways. *Nurs Case Manag*. 1997;2:127–129.
22. De Luc K. Are different models of care pathways being developed? *Int J Health Care Qual Assur*. 2000;13:80–86.
23. Redick EL, Stroud AR, Kurack TB. Expanding the use of critical pathways in critical care. *Dimens Crit Care Nurs*. 1994;13:316–321.
24. Zander K, McGill R. Critical and anticipated recovery paths: only the beginning. *Nurs Manage*. 1994;25:34–37.
25. Greenfield E. Critical pathways: what they are and what they are not. *J Burn Care Rehabil*. 1995;16:196–197.
26. Crummer MB, Carter V. Critical pathways–the pivotal tool. *J Cardiovasc Nurs*. 1993;7:30–37.
27. Van Wersch A, Bonnema J, Prinsen B, et al. Continuity of information for breast cancer patients: the development, use and evaluation of a multidisciplinary care-protocol. *Patient Educ Couns*. 1997;30:175–186.
28. Harkleroad A, Schirf D, Volpe J, et al. Critical pathway development: an integrative literature review. *Am J Occup Ther*. 2000;54:148–154.
29. Bailey R, Weingarten S, Lewis M, et al. Impact of clinical pathways and practice guidelines on the management of acute exacerbations of bronchial asthma. *Chest*. 1998;113:28–33.
30. Hill M. Outcomes measurement requires nursing to shift to outcome-based practice. *Nurs Adm Q*. 1999;24:1–16.
31. Bruckman RZ, Harris JS. Occupational medicine practice guidelines. *Occup Med*. 1998;13:679–691.
32. Fallon JB. Occupational medicine. The essentials of finance. *Occup Med*. 1989;4:49–58.
33. Belgian Royal Decree of March 27th 1998 Concerning Policy for the Well-Being of Employees at Work [Dutch].
34. Belgian Royal Decree of March 27th 1998 Concerning Internal Services for Prevention and Protection at Work [Dutch].
35. Belgian Royal Decree of March 27th 1998 Concerning External Services for Prevention and Protection at Work [Dutch].
36. Belgian Law of August 4th 1996 Concerning the Well-Being of Employees at Work [Dutch].
37. Gordon M. Steps to pathway development. *J Burn Care Rehabil*. 1995;16:197–202.
38. Coffey RJ, Richards JS, Remmert CS, et al. An introduction to critical paths. *Qual Manag Health Care*. 1992;1:45–54.
39. Cordell JL. A guide to developing clinical pathways. *Med Lab Obs*. 1995;27:35–39.
40. Ferguson LE. Steps to developing a critical pathway. *Nurs Adm Q*. 1993;17:58–62.
41. Giffin M, Giffin RB. Critical pathways produce tangible results. *Health Care Strateg Manage*. 1994;12:17–23.
42. Ibarra V, Titler MG, Reiter RC. Issues in the development and implementation of

clinical pathways. *AACN Clin Issues*. 1996;7:436–447.
43. Pearson SD, Goulart-Fisher D, Lee TH. Critical pathways as a strategy for improving care: problems and potential. *Ann Intern Med*. 1995;123:941–948.
44. Reinhart SI. Uncomplicated acute myocardial infarction: a critical path. *Cardiovasc Nurs*. 1995;31:1–7.
45. Wieczorek P. Developing critical pathways for the operating room. *AORN J*. 1995;62:925–929.
46. Deming WE. *Out of the Crisis.* Melbourne: Press Syndicate of the University of Cambridge; 1982.
47. Stewart P, Stenzel M. Exposure assessment in the occupational setting. *Appl Occup Environ Hyg*. 2000;15:435–444.
48. Kogi K. Practical approaches to the assessment of work-related risks. *Int Arch Occup Environ Health*. 1993;65:11–14.
49. Grosjean R. European standardization: guidance on the assessment of occupational exposure to chemical agents CEN TC 137. *Analyst*. 1994;119:9–12.
50. European Norm EN 689. *Workplace Atmospheres: Guidance for the Assessment of Exposure by Inhalation to Chemical Agents for Comparison With Limit Values and Measurement Strategy*. European Committee for Standardisation; 1995.
51. *Biological Monitoring of Chemical Exposure in the Workplace*, vol 1. Geneva: World Health Organization; 1996.
52. Anderson LK. An introduction to activity-based costing. *J Dent Educ*. 1996;60:384–389.
53. Asadi MJ, Baltz WA. Activity-based costing for clinical paths. An example to improve clinical cost & efficiency. *J Soc Health Syst*. 1996;5:1–7.
54. Abreu BC, Seale G, Podlesak J, et al. Development of critical paths for post-acute brain injury rehabilitation: lessons learned. *Am J Occup Ther*. 1996;50:417–427.
55. Dowsey MM, Kilgour ML, Santamaria NM, et al. Clinical pathways in hip and knee arthroplasty: a prospective randomised controlled. *Med J Aust*. 1999;170:59–62.
56. Esler R, Bentz P, Sorensen M, et al. Patient-centered pneumonia care: a case management success story. *Am J Nurs*. 1994;94:34–38.
57. Zander K. Nursing case management: strategic management of cost and quality outcomes. *J Nurs Adm*. 1988;18:23–30.
58. Cardozo L, Aherns S. Assessing the efficacy of a clinical pathway in the management of older patients hospitalized with congestive heart failure. *J Healthc Qual*. 1999;21:12–16.
59. Baker CM, Miller I, Sitterding M, et al. Acute stroke patients comparing outcomes with and without case management. *Nurs Case Manag*. 1998;3:196–203.