A DESIGN STUDY OF SUSTAINABLE INFECTIOUS WASTE MANAGEMENT SYSTEMS FOR SMALL HEALTHCARE PROVIDERS IN NORTH-EASTERN THAILAND

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Abstract: This paper outlines the methodology, based on a systems design approach, used to investigate and develop an improved model of an infectious waste management system for small healthcare providers in North-Eastern Thailand, mindful of sustainability and health care requirements. As will be explained, this research is based on quantitative and qualitative mixed-methods of enquiry and data collection including surveying the views of groups of professionals from ten representative small healthcare providers. These groups of participants (representing the main stakeholders) included administrative staff and medical doctors, nurses and practitioners, and unskilled operational staff. Based on empirical interview survey data obtained from these groups, a parametric model of an infectious waste management system (IWMS) has been developed in order to identify the relevant parameters and constituent variables underpinning the effectiveness of the system. This model of an IWMS has seven important functional parameters, namely: (1) planning and design of the system, (2) administration and policy, (3) individual departmental procedures, (4) sustainable, infectious waste disposal methods, (5) periodic and monitoring and control, (6) commonly used products and equipment, and (7) prevailing cultural and social norms. It is supported by detailed empirical data of which a relevant sample will be presented and discussed. It will be shown that the systems design approach, along with related empirical investigations (inclusive of stakeholder views) can lead to improvements in the design and operation of infectious waste management systems for small health care providers in NE Thailand.

Keywords: infectious waste, infectious waste management system, small healthcare providers, system design

INTRODUCTION

Well-designed infectious waste management systems (IWMs), and related products, are essential elements in maintaining hygiene and minimizing infections in hospitals. Nowadays, thousands of tons of infectious waste are produced by small health care providers (SHCPs) in the public service sector that have not been collected and treated appropriately according to sustainable procedures. And this is happening in many developing countries, especially in rural areas in North-Eastern (NE), Thailand. In these areas, IWMs are not well developed and related facilities and equipment need to be improved from both design and procedural points of view. Relatedly, an overview of infectious waste management (IWM) issues in South-East Asia – as found from the literature – has indicated that treatment technologies and disposal processes in the noted areas are poorly managed, particularly with respect to segregating and disposing waste in a sustainable and environmentally safe manner.

Well designed products, containers and packaging for waste disposal are generally very expensive to

purchase and difficult to include in the management policies of SHCPs – thus it is not surprising that recycled containers (e.g. glass and plastic bottles, plastic boxes, and various cans) are commonly used as part of the system procedures. This may be acceptable if some standardization and control procedures are part of an IWMS. In addition, the culture of individualism, traditional organization and hierarchical relationships between personnel in existing systems need to be considered sensitively in the design of such IWMs. From the noted literature review, it is apparent, as discussed below, that further studies are urgently required for understanding the design and management of IWMS for SHCPs so that possible improvements can be identified for future operations.

LITERATURE REVIEW

Preamble

This literature review briefly covers three main areas relevant to the design of infectious waste management systems, namely: an outline of the infectious waste management situation in NE Thailand, products commonly used in IWMs, and the prevailing cultural and social views of health care professionals.

Infectious waste management situation in NE, Thailand

In Thailand, the Ministry of Public Health (MoPH) is the main organization setting policies and controlling health care industries and the health of the people. The principle legislation related to IWM is the Public Health Act 1992 and the Healthcare Facility Act 1998. The Public Health Act specifies that local government shall provide disposal facilities for infectious and industrial non-hazardous waste. The Department of Health (DoH) and the Department of Pollution Control [1] have claimed that the procedure for collection, transportation and disposal of clinical waste is the responsibility of each health care provider who must comply with criteria specified by the DoH. Approximately 10-25 percent of the waste generated by health care providers is hazardous waste [2].

Other estimates of infectious waste indicate that the amount could rise to 28 percent by 2012 [3]. In relation to the overall issues, the IWMs of SHCPs appear to have problems with respect to: (1) definition of responsibilities and authorities in charge, (2) sufficient research data about system design and management, and (3) possibly inadequate, ongoing financial support. In addition, (4) inappropriate system procedures are often used, e.g., handling of medical waste in the public sector hospitals often does not pass standards established through related training programs, and finally, (5) according to the regulations of the MoPH, there is little use of international hazard warning symbols, tags and labels, approved waste handling containers and disposal and tracking procedures [4, 5, 6].

Moreover, in relation to other areas of IWMs, there have been three main ways of infectious waste disposal in Thailand; namely: (1) 50% of medical waste from hospitals under the MoPH has been disposed of by private companies, (2) 30% has been destroyed in onsite incinerators, and (3) the remaining 20% is managed by local authorities [1]. According to the latter reference and the changing expectation of improvements in healthcare's standards, the number of private managing organizations for infectious waste disposal is increasing. However, there is still no systematic control measure of the effectiveness of disposal procedures by these organizations [7].

Hansakul, et al [8] have provided an overview of private, waste handing organizations and concluded that: (1) separation of infectious waste is poorly managed, (2) vehicles used for infectious waste transportation do not conform to international standards (i.e., World Health Organization (WHO) or Environmental Protection Agency (EPA) standards), (3) infectious waste storage facilities lack temperature control systems and need more attention to specific design details, and (4) waste management personnel, especially unskilled employees of both health care providers and private companies, lack an awareness of sustainability principles and safe working practices, including the use of protective clothing and equipment. In the light of the above problems and issues, a design study of SHCPs in NE Thailand is urgently required. Other health issues arise from the use of substandard waste handling products and equipment as outlined hereunder.

Products and equipment commonly used in IWMs

In the domain of IWMs, equipment and products can be categorized into two functional applications, namely: (1) personal protection equipment (PPE), and (2) collection and transportation containers and products. Use of PPE reduces injuries and minimizes exposure from infectious agents for the wearers. PPE includes gloves, protective eyewear, masks and respirators, aprons, gowns, boots and shoe covers, ear plugs and caps/hair covers [9, 10]. However, if a SHCP cannot provide PPE or infectious waste handling containers for its staff, it has been suggested that suitable available materials can be used instead of standardized equipment [11], although this may be problematic, as noted earlier, unless some form of managerial control is implemented.

Panyaping and Okwumabua [12] have made a number of suggestions regarding the handling of

infectious waste in SHCPs, namely: (1) waste collection and transportation within a hospital should be segregated from other goods and clinical spaces, (2) off-site vehicles used to transport infectious waste should be constructed so as to separate the driver's cabin from the vehicle's cargo compartment, (3) PPE, chemical disinfectant and cleanup kits should be carried in separate vehicle compartments, and (4) universal biohazard symbols, and the names and addresses of the contract carriers should be marked on the body of the vehicles [9, 13]. While these suggestions are clearly important and useful, it is apparent that an overall or systems approach to improving the design – and, hence, the management and sustainable operation – of IWMs is needed. The socio-cultural aspects of IWMs are also an important parameter as outlined below.

The cultural and social views of healthcare personnel

Culture and social understanding are very important, perhaps critical, components of IWMs in the SHCPs context. Thai culture has unique characteristics which have been described in the publication "Culture, Communication and Nursing" [14]. According to this reference, the principle of collaboration in health care establishments has been described as being non-hierarchal. However, staff roles in health care providers have changed because of several factors such as new technologies, political issues, economic pressures and increasing service demands, especially nursing roles in which the boundaries of responsibilities have been raised leading to confusion about staff roles. Coombs [15] has outlined typical hierarchical relationships as reflected by inter-personal conflicts between doctors and nurses and also other types of staff. It is apparent that hierarchical issues in healthcare still occur, not only in South East Asian countries but in Western countries as well [15, 16].

The hierarchal environment in SHCPs (in NE Thailand) usually takes the following lines: medical doctors have senior status – questioning or challenging issues by nurses or other levels of staff rarely occur in keeping with Thai culture, and also Buddhist traditions in which to be quiet and thoughtful of others are important values [14, 17]. In addition, there are often vast differences in terms of financial incentives between doctors and lower-level staff, especially unskilled workers who do not have career development prospects or sufficient welfare pensions after retirement. These hierarchical and financial differences may have a significant influence on the design variables affecting IWMs [18]. These differences may also have negative consequences on the operation of an IWMS as reflected by stressed lower level staff resulting in possible staff under-performance, increase in accidents and mistakes, and decline in productivity and quality of health services, etc [19].

It follows that any design of an IWMS needs to adopt a sensitive approach to the possible socio-cultural differences of key stakeholders in the system, since the collective efforts of the latter are what makes the system effective.

STUDY RESEARCH METHODS

Preamble

The research methods employed in this study will now be explained beginning with an overview of the systems design approach. This will be followed by a brief outline of Grounded Theory and the multi-method research approach utilized in the study. Then a graphic outline (Figure 1) of the research methods employed will be presented along with an explanation of the relevant procedures involved and the selection of participants.

A system design approach to modeling IWMs for SHCPs

A few explanatory remarks about what constitutes a *system* and a *systems approach* are in order. A *system* is a generic term which has many possible meanings, but in a design context it can be taken to mean a set of "objects" where these objects are the interconnected components of the system as a complex whole [20, 21, 22, 23, 24]. In addition, the components of the system (i.e., the objects or *parameters*) usually have their own individual set of interconnected *attributes* or *constituent variables*. Systems can vary enormously in complexity and scale and, in many cases, often require a multidisciplinary *design* team to plan, analyze, design and implement the physical and operational system parameters, including the required human resources, technology (hardware and software) and standard operating procedures, bearing in mind sustainability principles.

But complex systems can also be relatively small in scale, such as an infectious waste management system (IWMS) suitable for small health care providers (SHCPs), in keeping with the subject of this paper. However, even though the noted multidisciplinary team would normally be required in a substantial development of such a system, the systems design approach can still be used to investigate and gain a better understanding of the main parameters of such a health care system. A key issue, of course, will be the cooperation of specific participants (i.e., the stakeholders) so that their views and aspirations can be better appreciated as explained in more detail later.

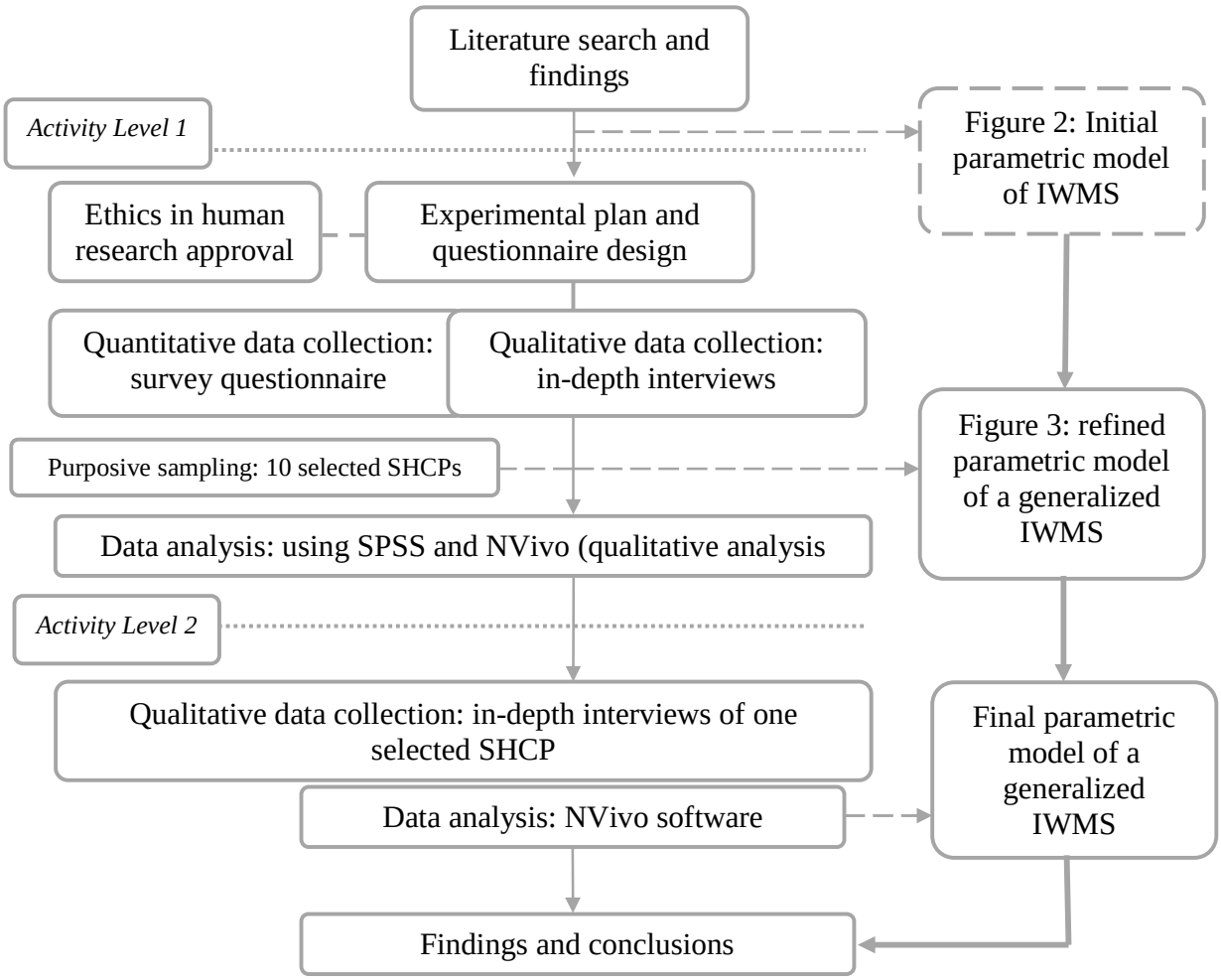


Figure 1: Graphic outline of the methods adopted in this research

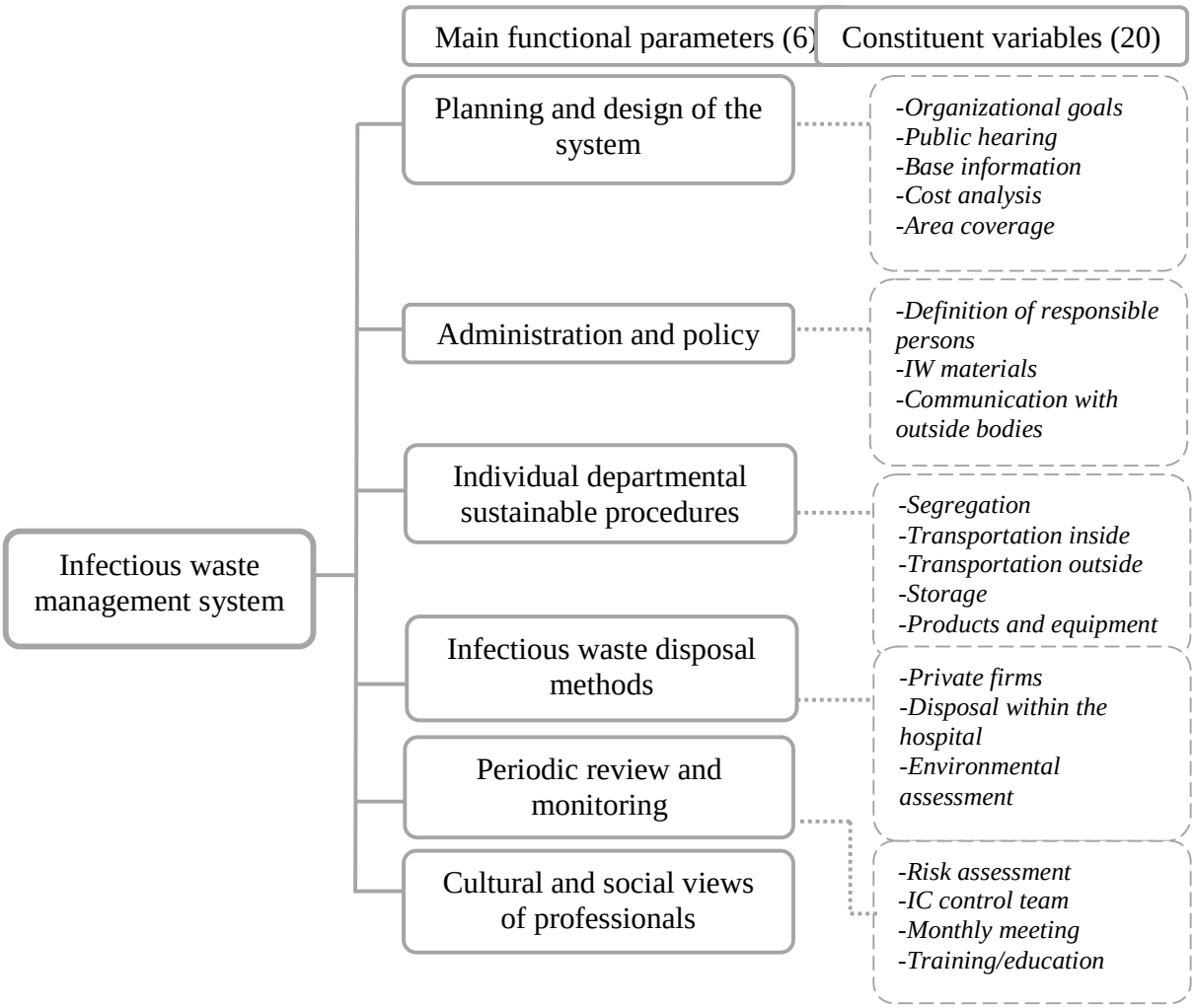


Figure 2: Initial parametric model of generalized IWMS

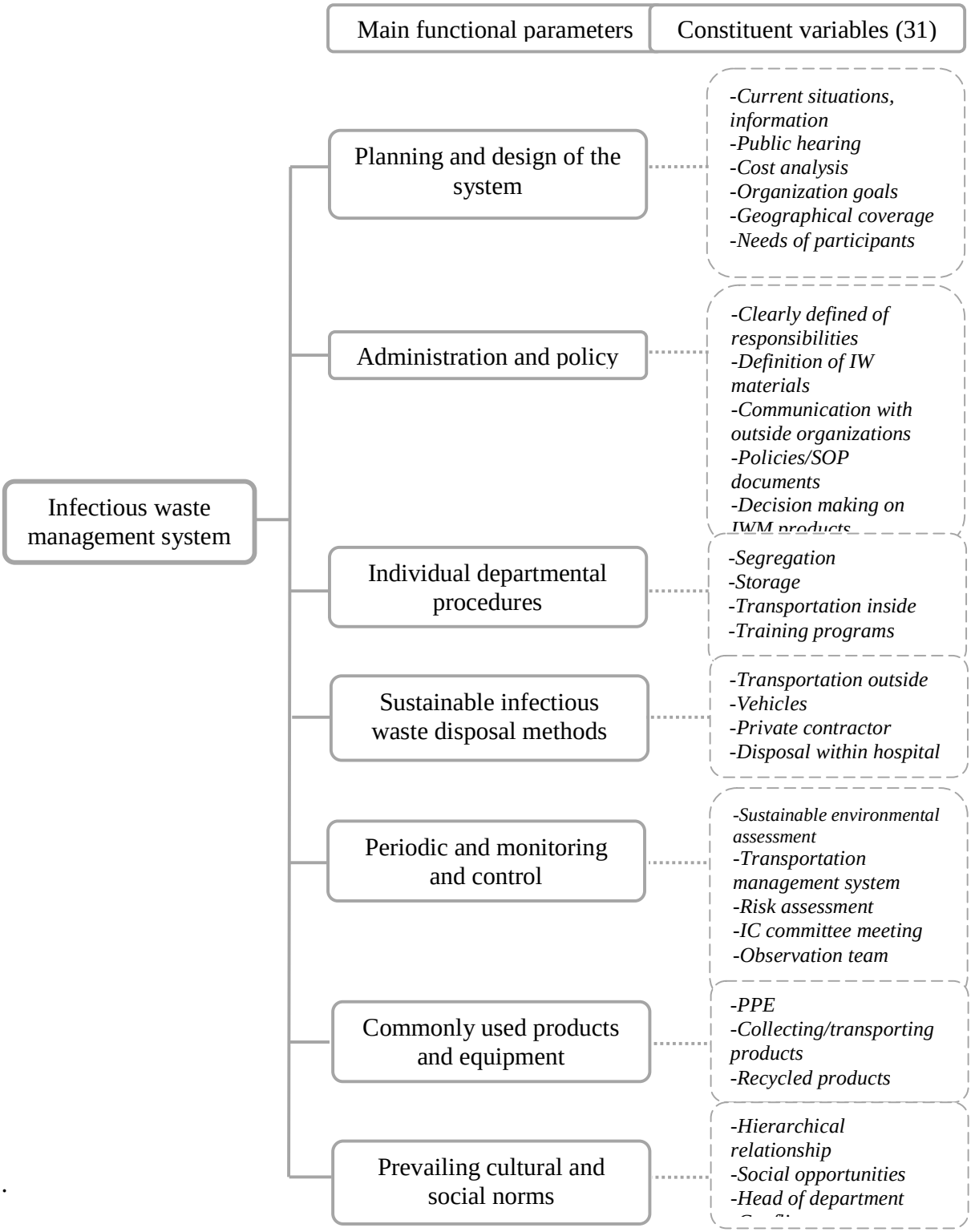


Figure 3: Refined parametric model of a generalized IWMS

Understandably, the inclusive design of a complex system, such as an IWMS, is largely dependent on the participation and contributions of individuals who have their own set of values [20]. In this study, the participants in the system included medical doctors, infection control nurses, and day-to-day officers (including the provider management team) who were interested in gaining a better understanding of the whole components (objects) of the system with a view to implementing improvements.

Application of Grounded theory

Selected aspects of grounded theory have been employed in this research: By way of explanation, Grounded Theory is theory based on empirical evidence systematically acquired through social research. It is may be loosely interpreted as discovery of theory from data [25, 26, 27]. In the SHCPs context, the research objective of this study has been to progressively understand what is happening in the respective SHCPs, and how participants in the related IWMSs manage their tasks and roles. Interestingly, Dick [28] has claimed that the key feature of grounded theory is the more or less simultaneous collection and analysis of data using a process known as constant comparative analysis.

Multi-method research: Quantitative and qualitative

The use of qualitative and quantitative methods within the same research project, also known as mixed or multi-methods, is often employed to provide more than one perspective of complex phenomena mindful of the strengths and weaknesses of each method, especially in the context of this study [29, 30]. A multi-method approach can lead to a more comprehensive explanation of empirical data. This approach is consistent with using both positivist and interpretivist viewpoints [26], and different elements of a study (related to different questions) may often need different methodological responses. In this study by the authors, the collection of empirical data and system modeling has followed several phases as explained further in *Figure 1*.

As depicted in Figure1, the first level of research activity employed in this study (apart from the literature review and experimental plan) was based on a Likert style survey (42 participants) as well as in-depth interviews of selected participants (19) in ten SHCPs (refer to list in Appendix A). The *initial* parametric model of a generalized IWMS, as theorized from the finding of the literature review, is found to have six main functional parameters as shown in Figure 2, namely: (1) planning and design of an IWMS, (2) administration and policy, (3) individual departmental procedures, (4) waste disposal methods, (5) monitoring and periodic review, and (6) cultural and social views of system professionals.

This model has twenty related constituent variables as shown. This *initial* model is, understandably, incomplete since additional parameters would likely become noticeable on obtaining qualitative interview data.

Participant selection

The participants involved in this investigation were categorized into three main groups, namely: (G1) administrative staff and medical doctors, (G2) nurses and technicians and (G3) unskilled staff. Groups G1 and G2 are usually involved in decision making related to the management and control direction of the IWMS. Their views directly influence the effectiveness of the IWMS and, no doubt, play an important role in implementing improvements to the system. Group G3 is responsible for carrying out the bulk of the waste materials handling functions in the SHCPs. This group generally acts in accordance with instructions from groups G1 and G2 and, ideally, would have required special training in waste handing methods consistent with the system procedures. This group would also be aware of the main problems associated with handing waste products and materials from a hazardous point of view.

As noted in the abstract, this paper is mainly concerned with the research methods employed in this investigation. Consequently, the discussion of selected experimental data is restricted to that gained from the first level of research activity shown in Figure 1, and then only on the basis of the qualitative interview data as will be explained later. The research methods employed in the second level of research activity are also outlined in Figure 1 where in-depth interviews involve participants in one of the ten SHCPs. However, the results of this level of activity will be reported in a subsequent paper due to the substantial amount of data involved.

As noted, both quantitative data (by analyzing the Likert style questionnaire data) and qualitative data (from in-depth interviews) were obtained in the first level of research activity. Data obtained from SPSS analysis (Statistical Package for the Social Sciences) identified the variables related to the existing parameters which required further study, and also the satisfaction levels of the participants with respect to the existing IWMs. Importantly, NVivo qualitative software [31] was used, as indicated below, to analyze the in-depth interview transcripts obtained from the in-depth surveys of ten SHCPs.

Table 1: Part A, depicting a refined model of a generalized IWMS – showing parameters and their constituent variables in NVivo software format (see also Figure 3).

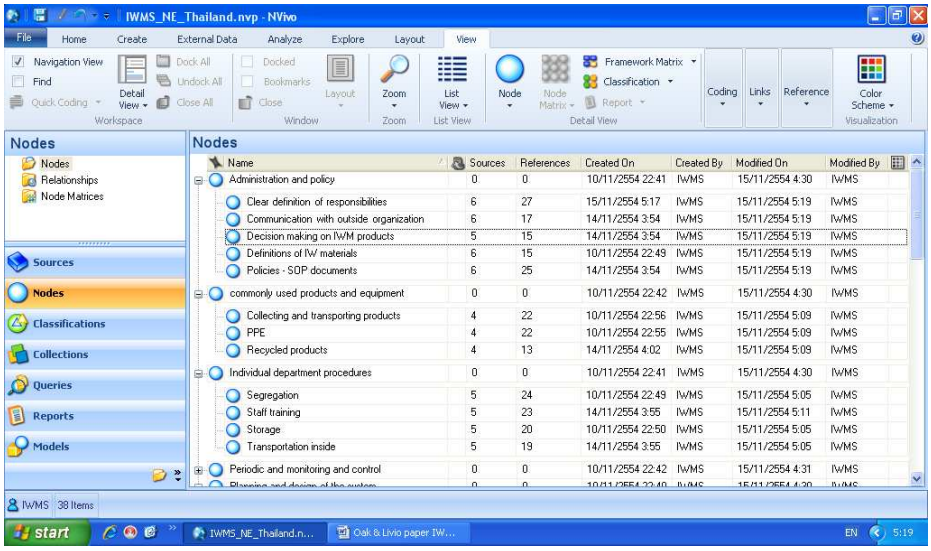
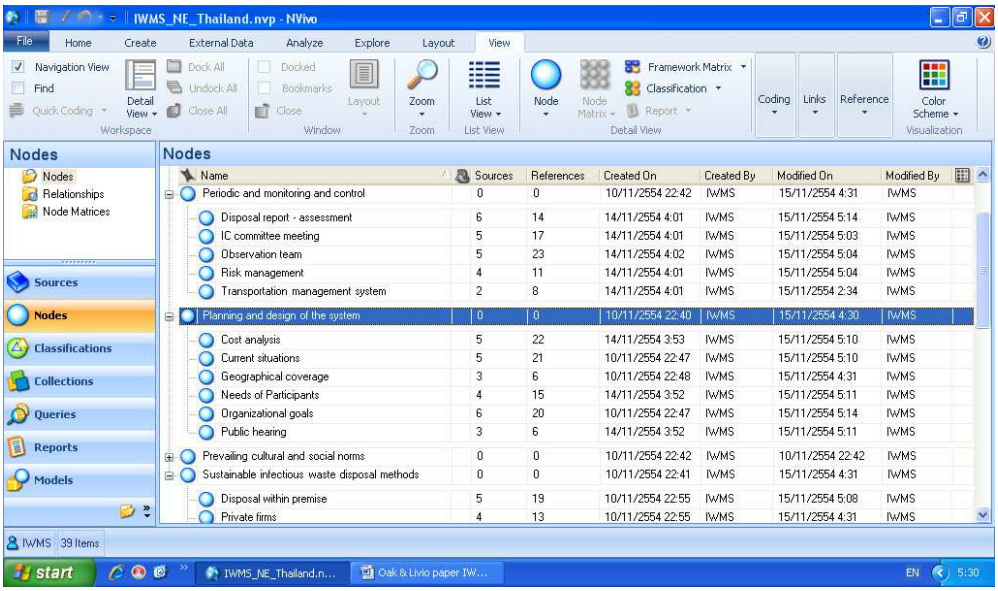


Table 1: Part B, depicting a refined model of a generalized IWMS – showing parameters and their constituent variables in NVivo software format (see also Figure 3).



APPENDIX A: List of participating SHCPs in North-Eastern Thailand (first level of research activity)

Selected Provinces	Hospitals-SHCPs	Number of participants for in-depth interviews
Udonthanee	Nonsaard Hospital	1
	Phasook Health Promoting Hospital	3
Nakhonratchasrima	Phratai Hospital	1
	Bualai Health Promoting Hospital	1
Khon Kaen	Khaosuankwang Hospital	1
	Namphong Hospital	2
Ubon Ratchathanee	Health Promoting Hospital District 7	6
	Muangsamsib Hospital	2
Srisaket	Kantrarom Hospital	1
Amnatcharean	Louamnat Hospital	1
Total number of participants		19

In turn, this enabled *parent nodes* (i.e., the main parameters) and *children nodes* (i.e., the constituent variables of these nodes) to be identified for a more complete, generalized IWMS as proposed in Figure 3 above (which, it will be noted, is a refinement of the *initial* model depicted in Figure 2).

Referring to Figure 3, it will be observed that the IWMS model now has seven main parameters (cf six in Figure 2) and thirty-one constituent variables, where some of the latter were not evident from the findings of the literature review as reflected in Figure 2. It follows that the qualitative data obtained from the first level of research activity has better informed the development of this model. It should be noted, however, that this model is still incomplete pending the analysis of data from the second level of research activity shown in Figure 1 (as noted above this will be discussed further in a subsequent paper). And, consequently, it may be possible to add further to the number of important parameters and constituent variables which affect the design, management and sustainable operation of an IWMS. A selection of qualitative experimental results obtained from the first level of research activity in this study will now be briefly presented and discussed.

SELECTED EXPERIMENTAL RESULTS

An example of the qualitative data obtained (using NVivo software analysis) from the in-depth interview transcripts of G1 and G2 participants (research activity level 1 – see Figure 1) is shown in Parts A and B, respectively, of Table 1.

For brevity, the other continuing parts of Table 1 have been omitted. The "Nodes" illustrated in Table 1, Part A, show the main system parameters (i.e., parent nodes) and the constituent variables (i.e., children nodes). The second column indicates the number of "Sources" (e.g., '6' corresponds to the number of subjects interviewed) and the "References" in the next column specify the frequency of key words or phrases mentioned in and coded from the interviews that were related to each of the constituent variables. For example, "Clear definition of responsibilities" was mentioned 27 times by two of the participants in groups G1 and G2. Here, the *frequency of occurrence* of terms related to the constituent variables can give an approximate indication (akin to Pareto's principle) of their relative importance as perceived by respective participants, and thus indicate areas of potential improvement.

Referring to the "Nodes" illustrated in Table 1, View B, the parameter "Planning and design of the system" includes six constituent variables, namely: (1) Cost analysis, (2) Current situations, (3) Geographical coverage, (4) Needs of participants, (5) Organizational goals, and (6) Public hearing. Here, the variable observed with the highest frequency was "Cost analysis" with a value of 22 from 6 sources. As another example, "Geographical coverage" and "Public hearing" were mentioned 6 times from 3 sources. Hence, on the basis of frequency, a priority for possible improvements may be assigned to the constituent variables on the assumption that the main parameters are all important, although human and environmental safety are fail-safe requirements of any system and must be met in practice.

CONCLUDING REMARKS

The literature review in this paper has found that, although there are useful guidelines and instructions related to the operation of IWMs in NE Thailand, further research in this field is needed to investigate the interdependent relationships of the parameters and constituent variables for IWMs in small health

care providers. This is especially the case for health care providers where a lack of resources can be a problem and systems may be underdeveloped for a variety of other reasons. This paper has described the research methodology used to investigate infectious waste management systems for small health care providers in North East Thailand, mindful of sustainability requirements. A design method for modeling existing IWMs has been proposed which is based on a systems design approach. Consequently, a parametric model has been developed and used to guide the related empirical investigation employing mixed, quantitative and qualitative methods of data analysis.

The refined model of an IWMS summarized in Figure 3 has provided a more complete conception of the characteristics of the IWMS investigated. However, as noted before, this model can be further refined when the results of the analysis of the qualitative data obtained from the second level of research activity (see Figure 1, and not included in this paper) is combined with the results of the data analysis noted in the first level of research activity. Nevertheless, the design approach used above to develop a parametric model of an IWMS is proposed as a powerful tool for investigating complex systems. It provides a useful framework for guiding mixed research methods leading to potential improvements in the design and operation of such systems.

In conclusion, it is heartening to report that the responses of the participants in the noted small health care providers surveyed has been very positive as they are keen to improve the health, safety and environmental impact of infectious waste systems under their control. This research is ongoing with more work to be done on the details of the IWM systems design, as well as the design and testing of related, sustainable products and equipments, under the second level of research activity.

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