DESIGN OF INFECTIOUS WASTE MANAGEMENT SYSTEMS: AN EMPIRICAL INVESTIGATION OF SMALL HEALTH CARE PROVIDERS IN NORTH EASTERN THAILAND

Thawon Niyompanitpatana* & Elivio Bonollo**
**Faculty of Architecture, Urban Design & Creative Arts, Mahasarakham University, Thailand, &*
***Faculty of Arts & Design, University of Canberra, Australia*
oak_ar11@hotmail.com; livio.bonollo@canberra.edu.au

ABSTRACT

The overall aim of this paper is to outline the theoretical and experimental work involved in gaining important knowledge about the design and operation of specific infectious waste management systems. In particular, it reports on selected extracts from a design-based investigation of infectious waste management systems (IWMs) for small health care providers (SHCPs), in North Eastern (NE) Thailand, with particular reference to the analysis of empirical results pertaining to the design of such systems. These results were obtained by surveying the views of groups of doctors, nurses and technical staff from ten SHCPs, along with a sample of related experts, spread across a representative area of the Isan region of Thailand. The literature search and theoretical framework underpinning this investigation has been published earlier by the authors [Niyompanitpatana & Bonollo, 2012]. Hence, only relevant informative elements will be outlined here. As will be shown, a novel parametric model of an infectious waste management system for SHCPs has been developed progressively, based on a systems design approach and a mixed-methods research design for obtaining and analyzing qualitative and quantitative empirical data. This proposed model of the IWMS comprises seven main parameters and forty-three respective constituent variables. It is found that this provides a conceptual and practical framework of the main characteristics of the IWMs surveyed. It also affords SHCPs in the noted context with a systematic operational tool for evaluating and improving their respective IWMs; furthermore, this model has potential for deployment in other related situations subject to further research.

Key words: *systems design, infectious waste, models of infectious waste management systems, mixed-methods research design, qualitative and quantitative analysis tools, small health care providers*

INTRODUCTION

In previous work, the authors carried out a detailed survey of the literature on the nature, volume, management and handling of infectious waste by health care providers in Thailand across a wide range of private and Government and International agencies. The basic characteristics of

infectious waste management systems were also modeled initially by carrying out a thematic analysis of the literature by means of NVivo qualitative analysis software [Niyompanitpatana & Bonollo, 2012]. However, it became clear that this initial model was not sufficiently comprehensive and inclusive to apply in the context of this inquiry involving SHCPs in NE Thailand. Hence, it has been refined and validated by means of an empirical investigation based on the views of typical SHCP stakeholders, namely, doctors, nurses and technical staff involved in infectious waste handling and management. In brief, it is found from the literature that infectious waste management systems in NE Thailand are not well developed from both a design and procedural point of view [Department of Health, 2006; Wiriwutikorn, 2009]. There are apparently few international or regional initiatives in place to support the operation and development of IWMs for SHCPs [Visvanathan & Adhikari, 2006]. In addition, there is widespread use of inappropriate products and equipment for handling infectious waste, sometimes known as 'substandard equipment' based on *recycled containers* (e.g., discarded plastic containers used for collecting sharps infectious waste) [Eberle, et al, 2009]. Although some recommendations on the management and handling of infectious waste are being applied in SHCPs, no related empirical studies have been detected in the literature for SHCPs in NE Thailand. Hence, further research was seen to be urgently required and potentially worthwhile.

An operational parametric model of an IWMS has been developed by the writers as will be explained further below. This model is based on a pragmatic, mixed-methods research design (plan) in which SPSS and NVivo analysis software have been used to analyze empirical data obtained from a detailed survey of ten small health care providers in North East Thailand. This model provides a more complete conception of the characteristic of an IWMS in terms of seven main parameters[1] and forty-three constituent variables[2] (for more information see Niyompanitpatana & Bonollo, 2012; Niyompanitpatana, 2013). The research methods and noted empirical investigation will now be described in more detail.

RESEARCH METHODS

Two phases of empirical research activity have been completed and named research *Activity Level 1* and research *Activity level 2*, respectively. As explained further hereunder, these research activities have been supported through a combination of a *pragmatic approach*, a *mixed-methods research design* and associated aspects of *grounded theory*. The mixed-methods research design—also commonly referred to as a "*triangulation design*" or a "*concurrent mixed-methods procedure*" [Cresswell, 2009]—has been used to add validity to the experimental results. The application of these

[1] A system *parameter* may be interpreted to mean "any object, quantity or attribute that is used to describe the configuration and performance characteristics of a system design [Bonollo, 2010, p.91]

[2] A *constituent variable* may be interpreted to mean a related functional or performance element that is a constituent or component of a system parameter [*Ibid*, p. 91]

methods has led to the progressive formulation of a novel parametric model of an IWMS; this model is described below as informed by these empirical results.

MODELING AN INFECTIOUS WASTE MANAGEMENT SYSTEM

In general, a *system* is a generic term which is open to a number of interpretations in a design context, such as a descriptive *classification* or *taxonomy* of activities and related information. A *systems design* approach can be used to investigate and gain a better understanding of the main parameters—and their interconnected constituent variables—of the IWMs of small health care organizations [Kendall & Kendall, 1988; Klimek & Bonollo, 2011; Bonollo, 2010]. In this study, the participants in the system included medical doctors, infection control nurses, and day-to-day officers (including the health care provider management teams) who were very interested in gaining a clearer understanding of the *parameters (or objects*) of their infectious waste management systems with a view to implementing possible organizational and operational improvements.

Selection of Participants

The total number of participants involved in research *Activity Level 1* was 30 (for Likert style questionnaire surveys), while 23 participants were involved in answering semi-structured, open-ended interview questions. In the case of research *Activity Level 2*, one small community hospital was selected because the hospital administrators were very keen to improve their IWMS. This hospital was selected as a follow-up study in order to support the validity of the data obtained from the ten hospitals previously investigated. Here, four participants—one member of the Infection Control Team (who was also involved in research *Activity Level 1*), and three university experts in infectious waste management (two environmental consultants and one medical nurse)—were selected for semi-structured, open-ended interviews. The purpose here was to obtain an independent evaluation of the proposed parametric IWMS model developed from research *Activity Level 1*. To proceed further, all the participants involved in this investigation were categorized into three groups, as follows: *Administrative staff and medical doctors* (G1), *Nurses and technicians* (G2), and *Unskilled-staff* (G3).

Selected Experimental Results

As shown progressively hereunder, examples are tabled of qualitative data analyses (using NVivo analysis software) obtained from research *Activity Level 1* for participant G1 and G2, followed by a triangulation comparison and quantitative data analyses sourced from research *Activity Level 2*. As will be explained, the model of an IWMS shown below in Figure 1 (in NVivo software output format)—consisting of seven parameters and forty-three constituent variables—represents a substantial refinement of the initial model obtained from the noted thematic analysis of the literature. For brevity, only the research methods and analysis of results for the parameter, *Planning and Design of an IWMS*, are described in detail hereunder. Empirical data for the other six parameters were analyzed in a similar manner [a full account is given in Niyompanitpatana, 2013].

Qualitative Data Analyses

IWMS Model Parameter: *Planning and design of an IWMS*—research *Activity Level 1*: For this parameter, data were obtained from ten SHCPs and comprised 14 interviews (over 23 participants from groups G1 and G2 who were involved in the planning and development of IWMs). The coding steps used to identify the main parameters that emerged from the interview data were as follows: (1) identify the main themes, in this case the parameters and respective constituent variables of IWMS; (2) assign codes to the main themes; (3) classify responses under the main themes, and (4) integrate themes and responses into the text of a research report [Kumar, 2011; King & Horrocks, 2010]. This approach has been used by the authors to develop themes and the thematic structures which have been subsequently applied to inform the noted comprehensive model of an IWMS—and which may also be used to highlight potential improvements to the existing systems for the information of the stakeholders.

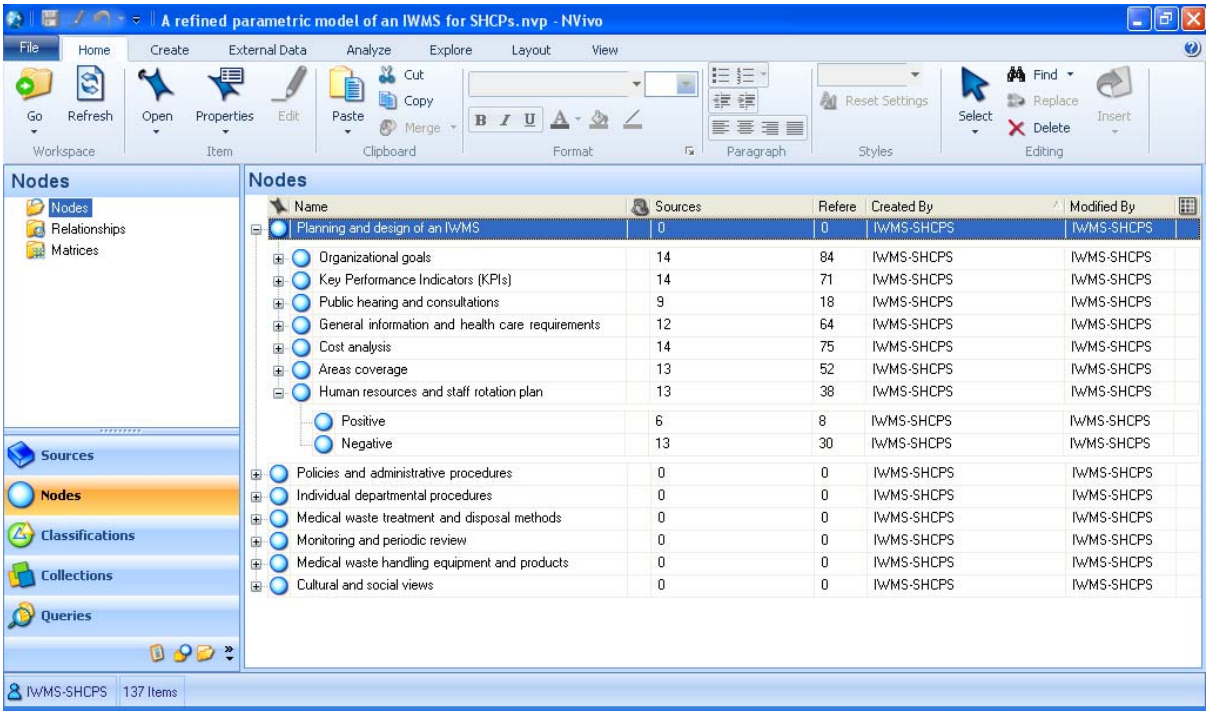


Figure 1: Listing the main parameters of an IWMS (NVivo software format), with details for the parameter *Planning and design of an IWMS* (data from 10 hospitals; 23 participants)

By way of explanation, Figure 1, above, provides a sample extracted from the qualitative analyses that summarized all of the NVivo software analysis outputs over the seven parameters. The *parent* nodes in Figure 1 *(e.g., Planning and design of an IWMS*) represent the main system parameters of the IWMS, and the *children* nodes (e.g*., organizational goals*) represent the respective constituent variables. This figure shows the seven main functional parameters detected in this inquiry of IWMs,

namely; (1) *Planning and design of an IWMS*, (2) *Policies and administrative procedures*, (3) *Individual departmental procedures*, (4) *Medical waste treatment and disposal methods*, (5) *Monitoring and periodic review*, (6) *Medical waste handling equipment and products*, and (7) *Cultural and social views*.

Observe also from this figure that the first parameter *Planning and design of an IWMS* includes seven important constituent variables, namely; (1) *Organizational goals*, (2) *Key Performance Indicators (KPIs)*, (3) *Public hearing and consultations*, (4) *General information and health care requirements*, (5) *Cost analysis*, (6) *Areas coverage*, and (7) *Human resources and staff rotation plan*. As shown for the variable (7) *Human resources and staff rotation plan*, participant responses were also categorized as *Positive*, or *Negative*—these two attitudes perceived by respondents indicated areas of potential improvements across all the noted parameters for the benefit of the participants. It will be seen that for *Planning and design of an IWMS*, the variable *Organizational goals* received 84 references from 14 sources indicating that the respondents viewed this variable as important to the system. Relatedly, the *Human resources and staff rotation plan* received 38 references of which 30 were negative, thus implying concerns by the participants with respect to this constituent variable. The number of *sources* in this figure indicate the number of interview transcripts actually obtained while the number of coded *references* denote how many times (i.e., the frequency) that respondents referred to a particular constituent variable. In this type of qualitative analysis, *frequency* may be interpreted as indicating the *approximate*, relative importance of a variable in the perception of the respondents, although this also needs to be cross referenced to corresponding quantitative analysis results as a check on validity.

The other six parameters listed in Figure 1 above were updated progressively in a similar fashion. A summary of coding references for the *Planning and design of an IWMS* parameter is given in Figure 2 below. This figure shows that the respondents in the ten SHCPs surveyed appear to be concerned with their existing IWMs. Thus, subject to the triangulation comparison discussed later with respect to the quantitative analysis results, it is found that these results suggest that the parametric model of an IWMS being developed is sensitive to the concerns of the respondents, and that potential improvements to the constituent variables of this parameter may be worth considering.

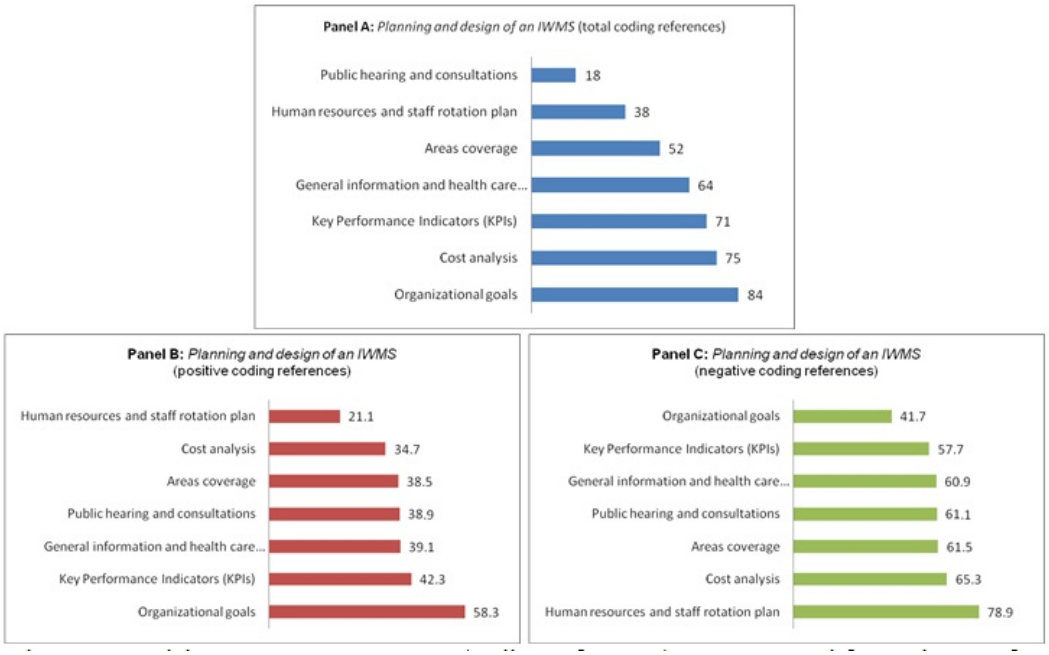


Figure 2: Participant response patterns (coding references)—as extracted from Figure 1 for the Planning and design an IWMS parameter (Panels B and C are % values)

Panel A in Figure 2, above, shows the total frequency of the references for the respective constituent variables of this parameter. At first glance, this appears to indicate the relative importance or priority, in the perception of the participants, of the respective constituent variables, and this is a reasonable assumption. However, when the positive and negative references are separated out, as in Panels B and C, and expressed as percentages of the total frequency for a particular constituent variable, the relative ranking of the coding references changes noticeably in relation to the total frequency of the coded references. This does not necessarily mean that the relative importance of the variables has changed; rather it indicates more clearly the level of satisfaction or dissatisfaction with that particular variable. These negative coding references (Panel C) highlight the relative concerns of the participants with respect to the noted variables and, hence, indicate possible areas for improvements.

Triangulation Analysis of Quantitative and Qualitative Results

IWMS Model Parameter: *Planning and design of an IWMS*—research *Activity Level 1*:

The results of a cross comparison of the quantitative and qualitative empirical results are tabulated in Table 1 below. For comparison purposes, the qualitative analysis results listed earlier in Figure 1 and Figure 2 have been included in this table alongside the quantitative analysis results for the three groups. In summary, the *qualitative* analysis results listed generally agree with the *quantitative* results, mindful of the expectations of a triangulation comparison in support of validity. These results have been ranked with respect to the highest *qualitative*, negative percentage response, beginning with 78.9% for *Human resources and staff rotation* and ranging down to 41.7% for *Organizational goals*, mindful of the overall ranking shown earlier in Figure 2, Panel A.

The next three columns, under the *quantitative* analysis heading with particular reference to groups G1,G2, and G3, show the instances in which relatively low mean values (on the Likert scale survey) were found for the respective constituent variables—these instances have been signified with an "X". It will be noticed that the "X" *quantitative* results line up reasonably well with the *qualitative* instances where high negative coding references were found in the qualitative analyses, hence, supporting the use of the mixed-methods research strategy used in this investigation.

Table 1: Cross comparison—Quantitative and Qualitative analysis results

Parameter: *Planning and design of an IWMS*

Constituent variables	Additional constituent variables	Qualitative analysis group G1 and G2			Quantitative analysis		
		NVivo coding references			*SPSS*		
		Total	Positive	Negative	G1	G2	G3
Human resources and staff rotation plan	✓	38	8 (21.1%)	30 (78.9%)	-	X	X
Cost analysis		75	26 (34.7%)	49 (65.3%)	-	-	-
Areas coverage		52	20 (38.5%)	32 (61.5%)	X	X	-
Public hearing and consultations		18	7 (38.9%)	11 (61.1%)	X	X	-
General information and health care requirements		64	25 (39.1%)	39 (60.9%)	X	X	-
Key Performance Indicators (KPIs)	✓	71	30 (42.3%)	41 (57.7%)	X	X	-
Organizational goals		84	49 (58.3%)	35 (41.7%)	-	-	-

These results suggest that, for the model parameter *Planning and design of an IWMS*, the related constituent variables—namely, *Human resources and staff rotation plan*, *Cost analysis*, *Areas coverage*, *Public hearing and consultations*, *General information and health care requirements*, and *Key Performance Indicators (KPIs)*—reflect a possible priority for implementing improvements to these variables. The *qualitative* analyses of the empirical data pertaining to the other six model parameters, although not presented here, were documented in keeping with the format for the parameter *Planning and design of an IWMS*.

Qualitative Data Analyses—*Activity Level 2*:

This involved a *qualitative* study—based on semi-structured, open-ended interviews that referred to the features of the proposed model of an IWMS noted above—for the purpose of identifying important concerns and recommendations of selected experts. These experts were first briefed on the purpose of the research and provided with details of the proposed model.

The response data for the four noted persons have been analyzed together based on an analysis of the themes shown in Figure 3 below. Three main response themes have been identified, namely; (1) *the overall views (of participants) with respect to the proposed model of an IWMS*, (2) *the parameters and constituent variables that SHCPs should focus on?,* and (3) *what additional parameters and constituent variables could be included in the proposed generic model of an IWMS*?

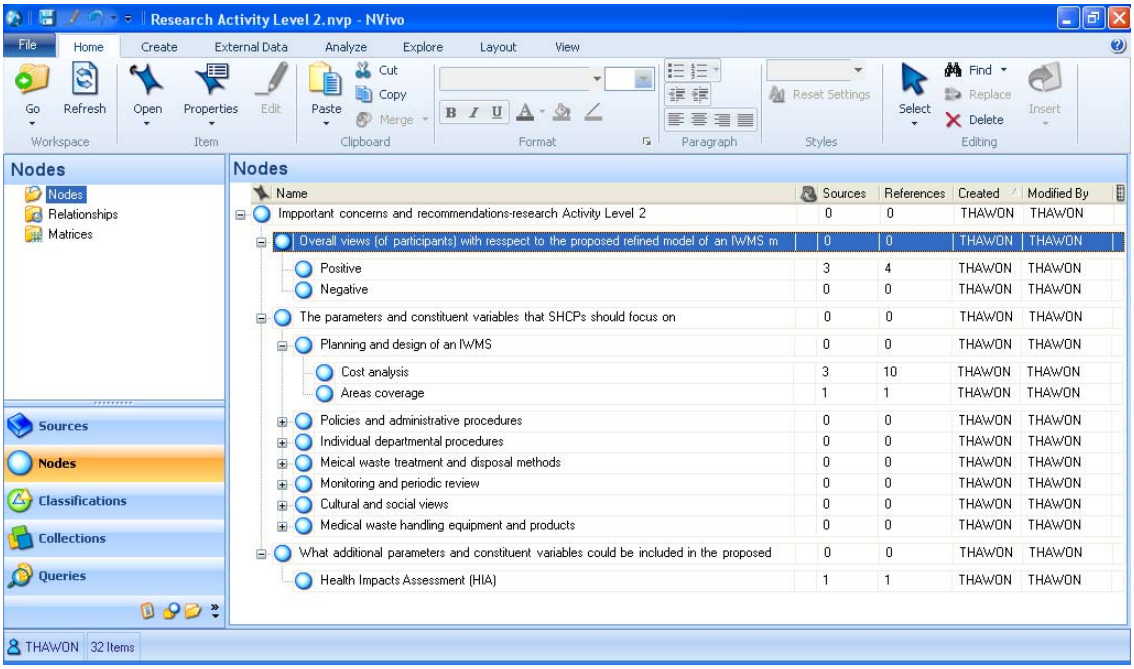


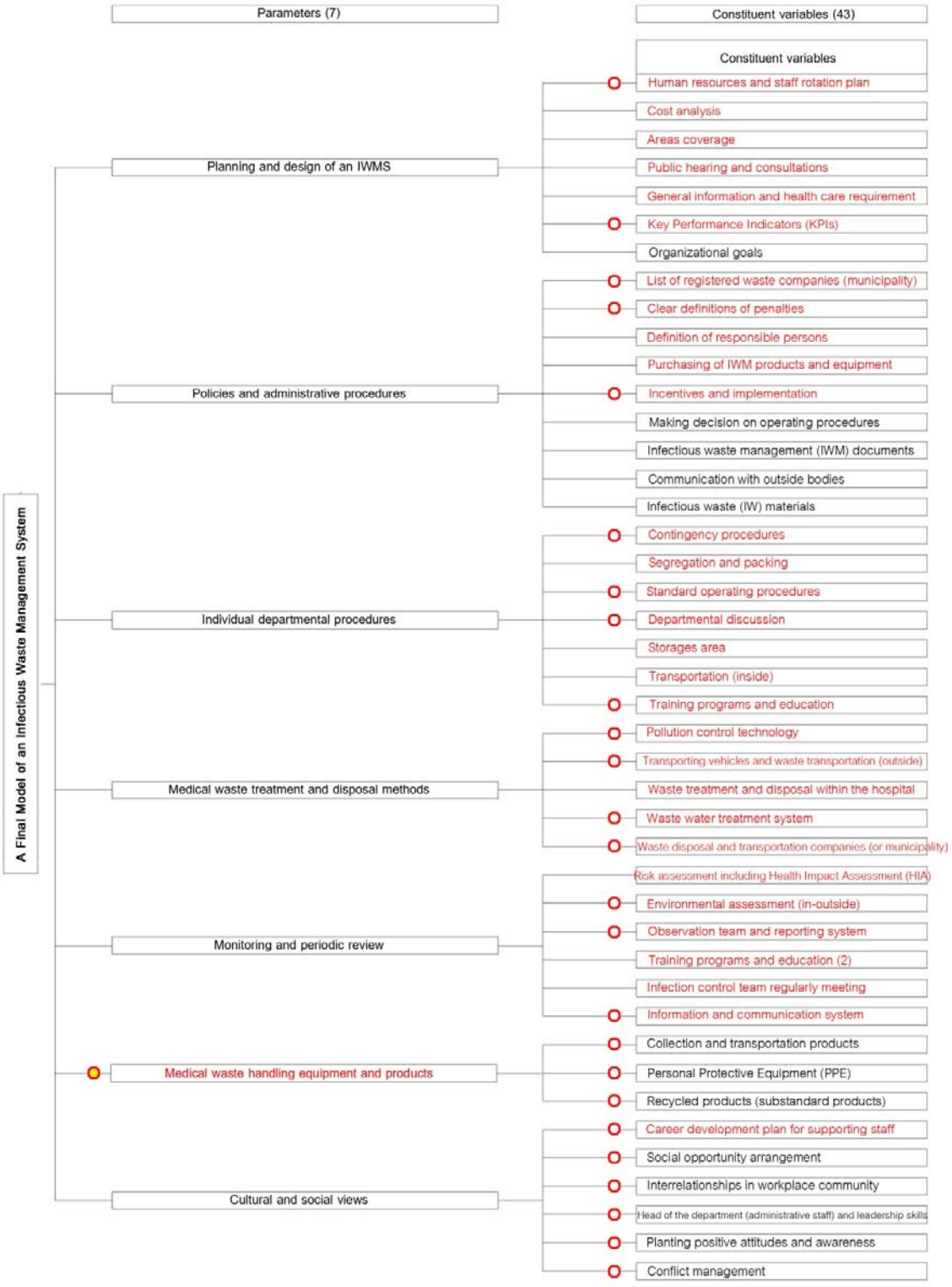
Figure 3: Listing the responses of related experts on the parametric model of an IWMS (NVivo software format)

Referring to Figure 3, for the first theme only, notice that there are four positive coding references from three sources (i.e., the three experts). With reference to the second theme, i.e., *the parameters and constituent variables that SHCPs should focus on*, the responses (but, for brevity, not shown in Figure 3 due to limiting the number of NVivo window panels) it was found that there was no particular concern at the level of the main parameters. However, at the constituent variables level, the respondents indicated that SHCPs should focus attention on the 18 important variables (out of the total of 43 variables) that had drawn a high number of negative references as noted earlier. Hence, these responses are found to be similar to the *qualitative* negative coding references noted before for variables in research *Activity Level 1*. Interestingly, this suggests that the experts were especially aware of shortcomings in and the need for improvement in these variables. In the opinions of these experts, it also reflects the relative importance or priority of potential actions with respect to these variables.

Finally, with respect to the third theme in Figure 3, that is, *what additional parameters and constituent variables could be included in the proposed generic model of an IWMS*?, one expert (an Associate professor in environmental science) emphasized that, *Health Impact Assessment (HIA),* as relevant to the proposed variable *Risk assessment*, was very important and should be included as an additional constituent variable for the model of IWMS. This, again, reinforces the validity of the proposed IWMS model. Hence, as supported by the positive responses of these experts, and apart from this amendment, the proposed parametric model of an IWMS was substantially confirmed as depicted hereunder.

Model of an Infectious Waste Management System

Figure 4: Proposed parametric model of an IWMS, based on the theoretical and empirical results described in this paper



Note ✿: The first importance priority based on the total number of coding references ●: Additional parameter ○: Additional constituent variable
x: Low mean values of Likert scale (Appendix C)

The model on of an IWMS proposed by the authors, as depicted in Figure 4, above, illustrates all of the parameters and respective constituent variables detected in this investigation in the noted context. In sum, the above model has seven important parameters and 43 constituent variables. These parameters are: (1) *Planning and design of an IWMS*, (2) *Policies and administrative procedures*, (3) *Individual departmental procedures*, (4) *Medical waste treatment and disposal methods*, (5) *Monitoring and periodic review*, (6) *Medical waste handling equipment and products*, and (7) *Cultural and social views*.

The *circled* values in Figure 4 represent the additional constituent variables identified progressively during the course of this investigation. This model of an IWMS provides a more complete conceptual framework of the characteristics of the IWMs investigated, mindful of the usual constraints and boundaries applying in this kind of research. As before, the constituent variables shown in Red represent variables which drew a high percentage of negative coding references (i.e., over 50% and also concerned by the noted experts) in the qualitative empirical investigations.

CONCLUDING REMARKS

Recall that the overall aim of this research was to investigate, gain important knowledge and further develop the design of infectious waste management systems appropriate for SHCPs in NE Thailand. The literature survey relevant to the design of IWMs has shown that further research is needed especially for small health care providers. The proposed parametric model of an IWMS provides the basis of a *descriptive* as well as an *operational framework*, or tool, for use by the SHCPs investigated. That is, it can be used as a checklist to systematically evaluate and make improvements to existing infectious waste management systems according to priorities established by the respective provider managements.

The respondents in the noted providers, and the noted experts, have identified which parameters and related constituent variables need to be further investigated mindful of implementing improvements. Although these observations regarding potential improvements apply generally over the ten SHCPs surveyed, they do not apply to any one hospital in particular. Understandably, it is largely up to the management of the individual SHCPs to consider further research in this area.

However, it is realized that this parametric model of an IWMS, although reasonably comprehensive, is not necessarily fully inclusive of the operations of many other SHCPs in NE Thailand. Future research is required to identify additional parameters and constituent variables not included above, and to provide related specific operational plans and checklists for individual health care providers.

On a wider scale, more collaborative research is required with relevant MoPH Governmental Officers to investigate IWMs on a national scale. Cultural and social norms may also be important elements to be researched in IWMS, [Burnard & Gill, 2008; Coombs, 2004; Nisbett, 2003], although their effects may be difficult to prove without further specific socially-oriented research. It is reasonable to

assume that any design studies of IWMs need to sensitive to the possible cultural and social differences since the collective efforts of all parties involved are what will probably make an infectious waste management system effective in the long run.

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