ORIGINAL ARTICLE

MERCURY-ADDED PRODUCTS MANAGEMENT: CHALLENGES IN DEVELOPING COUNTRIES AND LESSONS LEARNED FROM MEDICAL FACILITY

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ABSTRACT

The risks of mercury use have prompted the establishment of Minamata Convention on Mercury which placed strong emphasis on management of mercury-added products. This convention aims to reduce and phase out the use, manufacturing and trade of mercury-added products including batteries, switches and non-electronic measuring devices. This commitment will cause significant impacts especially in the developing countries in designing the right approach to achieve it. This is also true for medical industry which is well known for the utilization of mercury-added devices and dental amalgam in its services but had embarked on efforts in eliminating mercury for many years. The experiences learned within a medical facility can be useful in efforts to meet this global ambition of mercury phase out. This paper aims to provide conceptual discussion on the challenges faced by developing countries and lessons learned from medical facility that can helps the formulation of appropriate approaches to manage mercury-added products. The paper adopted medical industry as a case study and used document analysis to discuss the issue. The main challenges identified for developing countries include lacks of capacity, funding, data and newer technologies. Based on analysis of previous studies, this study proposed a mercury management framework in medical facility and identified the recommended practices, namely technological application, policy instrument, capacity building and guidelines development. These identified approaches are found to have specific relationships between cost and potential impacts, hence giving flexibility for adoption based on the available resources in promoting better mercury management system.

***Keyword**: Mercury-added product; medical facility; mercury management; Developing Countries*

INTRODUCTION

Mercury had been used in many forms including the elemental and compounds in various processes and industries throughout the history. According to Hylander, approximately one million tonnes of mercury were produced over the last 500 years and had evolved from the basic use such as ink to measuring equipment including sphygmomanometer and hygrometer[1]. Main industries that still utilizing and releasing mercury include mining, cement production, vinyl chloride monomer production, chlor-alkali production and consumer products manufacturing[2]. However, mercury use had caused significant risks to environment and human health as demonstrated in the unfortunate Minamata incident in 1950s-1960s and both the Iraqi's poisonings in 1960s and early 1970s[3].

Mercury can present as mercuric vapour, organic compounds or inorganic compounds which can be released into environment and ultimately enters the water bodies. Upon entering the water bodies, microbial activities can transform it into methylmercury which is the main contributor to mercury pollution. Methylmercury has the properties of biomagnification and bioaccumulation which causes the uptake of mercury into organisms and increase of mercury concentration along the food chain[4]. This causes deposition of mercury in fish and leads to the major source of mercury exposure to human which is through dietary of fish consumption[5-6]. Upon exposure, mercury and mercuric compounds capable of disrupting the nervous system, cardiovascular system, kidney and can be carcinogenic[7]. Children affected by Minamata incident exhibits mental retardation, coordination disturbance and growth disorder[8].The environmental and health risks of mercury become a global concern because mercury is a transboundary pollutant. Studies had proven that Arctic also experiencing mercury contamination mainly originated from East Asia through wind, ocean currents and rivers[9].

In 2009, the increasing concerns prompted United Nations Environment Programme (UNEP) to start an initiative for a globally legally binding instrument on mercury through series of negotiations with countries representatives which lead to the

establishment of Minamata Convention on Mercury[10]. The main objective of this convention is to protect human health and environment from anthropogenic emissions and releases of mercury and mercuric compounds[11]. This unique convention is solely dedicated to manage mercury and mercuric compounds along its entire life cycle covering mercury source, trade, mercury-added products, emission, releases, waste and capacity building.

This paper discusses management of mercury-added products through Minamata Convention and the challenges faced by developing countries. The paper also selected medical industry as a case study in analysing the recommended practices in improving the mercury-added products management.

METHODOLOGY

This paper adopted medical industry as a case study in discussing the concept of mercury-added products management, challenges in developing countries and lessons learned based on literatures from various agencies and research.

MINAMATA CONVENTION AND MERCURY-ADDED PRODUCTS

One of the main concerns in the Minamata Convention on Mercury is the mercury-added products (Article 4 of the Convention) including batteries, thermometers, paint and cosmetics. The convention defines mercury-added products as "a product or product component that contains mercury or mercury compound that was intentionally added" which covers the entire range of products but emphasizes on the product listed in Annex A (Part I and II) of the Convention[11]. These mercury-added products can be grouped into general broad groups in order to assist further discussion (Table 1).

Table 1. Groups of products, phase out dates and actions listed in Annex A[11]

Major group of products	Description	Phase out date / Actions
Batteries	Batteries, except for button zinc silver oxide and zinc air batteries with a mercury content < 2%	2020
Switches & relays	Switches and relays (with some specific exceptions)	2020
Lamps	Compact fluorescent lamps with ≤ 30 watts and >5 mg mercury per lamp burner	2020
	Linear fluorescent lamps including: (a) Triband phosphor with <60 watts and >5 mg mercury per lamp burner; (b) Halophosphate phosphor with ≤ 40 watts and >10mg mercury per lamp	2020
	High pressure mercury vapour lamps (HPMV)	2020
	Cold cathode fluorescent lamps and external electrode fluorescent lamps for electronic displays with length and mercury content specifically mentioned in the convention	2020
Cosmetics	Cosmetics (with mercury content above 1ppm) except eye area cosmetics.	2020
Chemicals	Pesticides, biocides and topical antiseptics	2020
Non-electronic measuring devices	Non-electronic measuring devices including barometers, hygrometers, manometers, thermometers and sphygmomanometers except those installed in large-scale equipment or those used for high precision measurement.	2020
Dental amalgam (Part II Annex A)	Dental amalgam	Parties need to conduct at least two of the nine mentioned measures

The Minamata Convention aimed to stop any process of manufacturing, import and export of products listed in Annex A (Part I) through establishment of phase out date with the exception as mentioned in the same annex[11]. As an alternative, parties may implement measures in

addressing the products, with proof of reduction of the activities to a de minis level[11]. To ensure sustainability of the convention, amendments of Annex A is allowed while it is clearly stated that any incorporation of assembled products containing mercury-added products is not allowed[11].Ultimately, the manufacturing and trade of majority of mercury-added products will be stopped by 2020 except for the granted exception, parties with proven de minimis level and products that are still being phase down[11].

MERCURY-ADDED PRODUCTS AND DEVELOPING COUNTRIES

The Minamata Convention will cause impacts at a global scale with difference magnitude for developed and developing countries. Developing countries will be a major player in ensuring the success of this convention due to current trends of chemical use and production. The Global Chemical Outlook prepared by UNEP shows general trend of increasing growth of chemical industries in developing countries led by China which tripled within 2000 to 2010[12]. The chemicals production trend indicates that bulk chemicals are focused in developing countries while complex and focused chemicals are mainly produced in developed countries[12]. The 2020 projections anticipate developing countries will dominates 31% and 33% of global production and consumption respectively further justify the importance of developing countries in global chemical management[12].

Production of batteries, lamps, switches and relays are part of the US$ 28.5 billion global electronics market[12]. Mercury is essential and highly concerned component in fluorescent lamps however the use is expected to grow[12-13]. A study in mainland China estimated the production of fluorescent lamps is projected to reach 11.90 billion units by 2020 from 9.40 billion units in 2015[14]. Mercury is used in fluorescent light bulbs to produce ultraviolet energy and later transformed into visible light[15]. A study in 2013 found that there are evidences of increased urinary mercury level in workers of fluorescent lamp factory in Egypt and called for effective preventive programs especially in the developing countries with the lowest hygienic measures[13]. Mercury contamination is also demonstrated in Bangalore, India where the soil contained high mercury in area of electronics productions than in nearby control site[12].

Cosmetics particularly skin lightening creams are part of concerning mercury-added products. According to World Health Organization (WHO), mercury is commonly utilized in skin lightening products in African and Asian countries to inhibit melanin formation[16]. A study in Mexico found high mercury cosmetics are widely available with the ingredients unclearly displayed[17]. Studies also found mercury in whitening creams and products from developing countries including Thailand, Lebanon, China, Pakistan, Philippines and Dominican Republic[16-17].

Use of mercury containing pesticides such as methylmercury dicyandiamide and phenyl mercury acetate can cause pollution due to the runoff water from agriculture sites. The increasing demands had shifted the industry to modern practices including the use of pesticides, where 1.5 million tonnes are manufactured annually and the amount continuously increasing[18-19]. There are still use of organochlorine insecticides including dichlorodiphenyltrichloroethane (DDT) and Aldrin in developing countries even though it had been banned in developed nations[20]. The scale of mercury pesticides use in developing countries still remain unclear but it is estimated 2,100 tonnes of mercury were released globally from the use as pesticides and fungicides in 1960s and the used had tremendously reduced since then[2].

Medical industry also uses mercury-added products especially dental amalgam and non-electronic measurement devices like thermometer, barometer, manometer and sphygmomanometer. In Cameroon, estimated 2,430kg of metallic mercury were consumed for thermometers production between 2006 and 2010[21]. Meanwhile, amalgam are widely utilized in dentistry and identified as a main source of environmental release[22]. In 2005 approximately 240-300 tonnes of mercury were used as dental amalgam globally[23].

CHALLENGES OF MERCURY-ADDED PRODUCTS IN DEVELOPING COUNTRIES

Complying with obligations of Minamata Convention will require changes in current practices at every phase from supply to disposal. There will be challenges especially faced by developing countries and need to be addressed wisely. Major challenges faced by developing countries include:

1. Lack of Capacity to implement the Convention

Mercury-added products management is a relatively new concept thus adhering to the already established phase out dates will be challenging for developing countries. Implementing measures and programmes will require adequate capacity from all the stakeholders including the government agencies, private sectors and communities. Changes in management structures, technical processes and trade activities are

needed, and inputs from stakeholders are important in promoting inclusivity and participation. Strengthening capacity will be useful either in gathering relevant opinions or implementation of planned programs and activities. The need to strengthen institutional, technical and legal capacities had explicitly mentioned by countries from Latin America and Caribbean in implementation of Minamata Convention on Mercury[24].

2. Lack of data and information available for decision makers

Designing relevant initiatives to improve management system will be highly depending on availability of reliable data. Lack of primary data including production, use, import and export of mercury-added products will increase the uncertainties of planned initiatives. Currently, it is commonly acknowledged that there are lacks of data in developing countries as observed in the establishment of Pollutant Release and Transfer Registry (PRTR) comparing to developed countries[12]. More than thirty countries have PRTR system and mostly are developed countries, however initiatives had been started in Belarus, Cambodia, Peru and others particularly with UNEP's support. Improving the relevant baseline data, through national assessment and relevant studies will be a major boost in mercury management agenda[25].

3. Need for newer technologies

Replacing and eliminating mercury-added products will depend on the availability, affordability, functionality and viability of substitutes. Alternatives are developed through newer technologies which are usually available in developed countries and technology transfers to developing countries are promoted through joint ventures, merging of companies and investments[12]. However, this process must be expanded to empower small and local industries to promote local manufacturing which will increase the availability and affordability of the products, as well promotes market shift.

4. Guidelines and know-how knowledge

The issue of mercury management received global attention within the last decade particularly through efforts of UNEP. The establishment of Minamata Convention on Mercury will requires changes in the current practices which do not emphasize on proper mercury management throughout the lifecycle. These practices can be improve through formulation of guidelines, suggestions and case studies that progresses towards sound mercury management. Currently, there are evidences of lower risk management standards of chemicals in developing countries compared to developed countries causing more risks for accident[12]. Sharing related experiences and guidelines by agencies and countries will be useful in influencing changes in current practices.

5. Inadequate Policy instrument

Effective governance framework including legislations, actors and processes are crucial in managing mercury-added product and remains as a challenge for developing nations. Formulating effective policy measures, equipped with adequate monitoring and enforcement activities are important in providing the right atmosphere that promotes positive economic growth, social well-being and environmental protection as aspired through sustainable development. Governance and policy instrument will become a tool in consolidating both voluntary and involuntary approaches while safeguarding the interest of all the stakeholders. However, governance processes are usually locally specific and this will require intensive discussions, capacity building, and relevant studies to tackle issue of mercury-added products management.

6. Shortage of financial resources

Mercury Convention requires parties to implement measures including phase out date, trade sanctions, as well as conducting needed research and reviews. Conducting these activities will need funding to facilitate assessment of the issue, exploring options for improvements, formulation and implementation of proposed actions at all levels. The convention had allocated funding for developing countries through Global Environment Facility (GEF) Trust Fund and will be under the purview of GEF and Conference of Parties[11]. However, parties including developing countries must provide resources for national activities based on its capabilities[11]. Allocating funding for these activities will be a big hurdle for countries that have limited financial resources.

7. Economic implications for countries that depend on mercury-added products

Trade sanctions and products phase out will inflict economic impacts on the related industries. This depends on the magnitude of the industries and the contribution to the nation's economy. As discussed earlier, mercury related industries are significant in developing countries but the exact scale of mercury dependence is unclear. Trade restrictions may cause significant reduction in economic growth, which will cause concerns from stakeholders especially the business sectors. Since phase down dates had been set, parties must take necessary actions in preparing the industries to ensure economic growth and market competitiveness.

Managing mercury-added products is a complicated process and involves industry-specific measures. It takes into account the production and the consumer end of every products and industries. Both the demands and supply must be reduced and ultimately stop wherever possible. As the concept of mercury-added products is relatively new, learning from the experiences of other industries will be useful in improving the management generally.

CASE STUDY: MERCURY-ADDED PRODUCTS MANAGEMENT IN MEDICAL FACILITY

Medical sector remains as consumer of mercury-added products despite the risks and danger mercury release and exposure to human health and environment. According to United States Environment Protection Agency (USEPA), medical waste incinerators contributed 13% of atmospheric mercury in United States[26]. Another study in Saudi Arabia found unacceptable level of soluble mercury in the wastewater from the dental clinics[22]. These become strong evidences of mercury use and the need for better mercury management in medical facility.

LIFE CYCLE MERCURY MANAGEMENT AND PRACTICES

Following the growing concerns of mercury, many documents had been published in promoting reduction of mercury use in medical industry. WHO consistently promotes the concept of mercury-free medical facility with the aim to phase out demands for mercury thermometers and sphygmomanometers by 70% and shift the productions to mercury free alternatives by 2017[27].The Minamata Convention on Mercury adopted a life cycle approach in managing mercury and this approach can be replicated in medical industry[11]. Using this approach as the base, the framework of mercury management can be illustrated as in Figure 1.

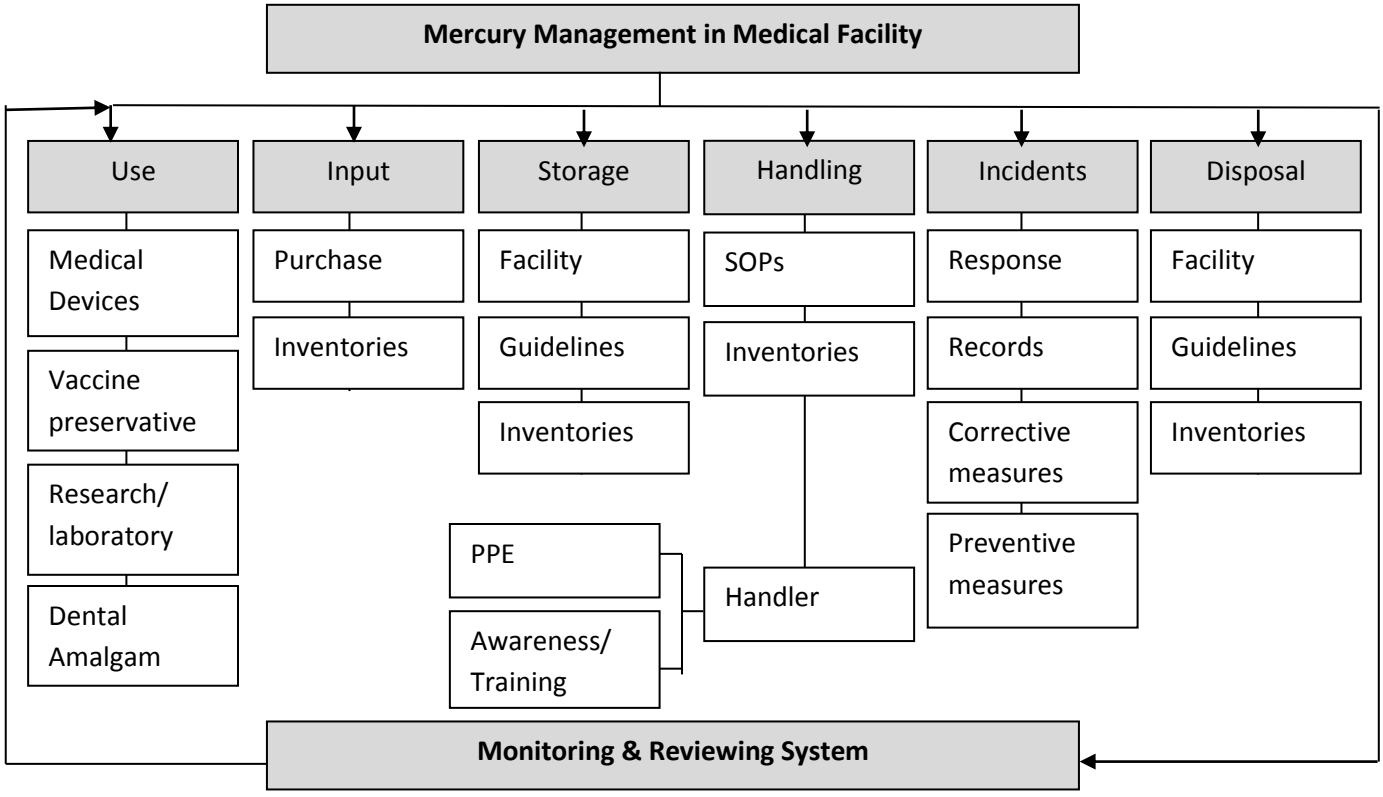

Figure 1. Life cycle approach of mercury management in medical facility

Use of mercury in medical facility is due to the demand which should be the starting point of the management system. Use and demand of mercury-added products must be identified by a multi-disciplinary teams and should be recorded using inventory to understand the scale of mercury use[26,28]. This will provide baseline data for monitoring of progress in mercury reduction programme and assists further planning processes in the future.

Input

The input of mercury into medical facility is through the process of procurement. Key actions in managing mercury input is by establishing in-house mercury-free purchasing policies or at least include plans to reduce the use of mercury-added

products and promotes use of alternatives[29-30]. In addition, vendors must disclose the mercury content of goods for careful evaluation before purchasing[26]. This will discourage the continuous use of mercury-based devices in a medical facility[29].

Storage

Once purchased, mercury must be stored properly in a specially designated facility and equipped with proper guidelines and inventories. Specific measures need to be practiced in ensuring proper storage including the use of closely tighten container and cool place for liquid mercury[23]. The access to the area must be limited to authorized personnel and inventories of stored materials must be closely monitored[23,29]. Guidelines for storage and transportation of mercury and mercury-added products must be followed to prevent undesirable risks.

Handling

Handling of mercury-added products is crucial and influenced by elements such as Standard Operating Procedures (SOP), inventories and the handler. Mercury used must be recorded in inventories for usage monitoring. Improper handling can result higher accidents rate and larger exposure to human including medical staff and patients. Proper SOPs and guidelines must be followed in all activities including preparation of dental amalgam, disposal of amalgam, calibration of mercury containing devices and handling of mercury containing vaccine. All responsible personnel must be empowered in mercury management through education, awareness and training. Mercury education and awareness had been identified as a core element in moving towards a mercury free medical facility[23,26,28,31,]. Meanwhile mercury specific trainings must cover the entire life cycle of mercury including the handling, accident response, storing and waste disposal[26,28,30].

Mercury accidents

Common accidents including thermometers break, mercury spills and occupational exposure causes significant risks to medical personnel, patients and visitors. A medical facility should adopt proper management practices which cover accident responses and clean up guidelines[29]. This includes the use of simple, complete, replenished and readily available mercury spill kits especially in the susceptible area[23,28,30]. Accidents must be recorded and monitored as an indicator of mercury management effectiveness. Appropriate corrective and preventive measures should be adopted and delivered through constant training and awareness.

Disposal

The final phase of mercury in medical facility is the disposal which can cause environmental pollution if handled wrongly. Mercury must be recovered as much as possible which then must be treated of hazardous waste or recycled[30]. Mercury must be disposed as separate hazardous waste and never incinerated with the rest of the waste[23]. Specific mercury waste management programme must be established including comprehensive guidelines covering waste collection, storage and labelling[28,30]. This includes establishing interim hazardous storage with adequate safety measures, clear guidelines and updated inventories[23]. Furthermore, efforts to establish a centralized centre for miscellaneous mercury-added product including lighting bulbs and batteries must be encouraged[26]. Investment on infrastructure upgrades including traps, end-of-pipe treatment, amalgam separators and wastewater monitoring apparatus for constant monitoring will help mercury waste management[23,26].

CATEGORIES OF RECOMMENDED PRACTICES AND THE RELATIONSHIP

Upon extensive analysis on recommended practices, it is found out that these recommendations can be classified into four main categories namely the policy instruments, capacity building, technological application and guidelines and procedures implementation.

Policy instruments

The establishment of a mercury-free medical facility is very much dependent on the commitments whether it is at the national, state, or individual medical facility level. These commitments can be in the form of policies or commitment letters which may be legally or not-legally binding. National policies on mercury based medical devices had successfully established in several countries including Philippines (2008), Argentina (2009) and Taiwan (2008)[27]. Established commitments will set the tone and targets and will support relevant initiatives such as substitution program, specific committee and training. Official commitment from the top management is crucial as this will influence the purchasing policy and trickle down to ensure success in other initiatives. Continuous top level supports will ensure the sustainability of the initiatives as well as appreciation to those committed in the cause. This effort must be supported by bottom up approaches including awareness raising activities by relevant stakeholders to ensure sustainability in mercury management.

Technological application

The advancement of technologies can boost mercury management especially in the aspect of

waste management and monitoring. Application of technologies such as substitutes, ambient monitoring or waste disposal will help in mercury management. However, this will induce extra cost to the operational budgets. This extra costing will be justified if the issue of mercury management is put as a priority and strengthen with the already established policies.

Guidelines and procedures development

While technologies provide hard solution, guidelines will serve as a soft solution and provide the opportunity of moving forward with quicker solution compared to the technological application. Establishment of inventories, SOPs and guidelines ensure the mercury is handled in the most appropriate ways at every phase of its life cycle. A well-maintained inventories will help the facility monitors the needs and usage of mercury and further improve of mercury-dependent operations. Adoption of recommended practices from various international and national agencies will help in improving mercury management.

Capacity and capability building

Staffs that directly and indirectly handle mercury are very important in mercury management in medical facility. Medical personnel must be well-equipped with awareness and capacity to prevent mercury related accidents due to human error. Awareness raising activities and education about risks and hazards, as well as the importance of mercury management will ultimately increase commitments. Medical personnel must have good capacity in conducting their routines correctly. Continuous trainings covering the whole mercury life cycle and elements including proper handling, maintenance of inventories and use of personal protective equipment must be emphasized. Consolidating the guidelines and training components will ensure sustainability in moving towards the same aim as targeted.

RELATIONSHIP WITH COST AND POSSIBLE IMPACTS

Costs and impacts are main characteristics in planning approaches for mercury management. The four determined categories have unique relationships with the needed cost and possible impacts (Figure 2). Understanding the potential costs and possible impacts is important in planning steps of promoting good mercury management. However, it is best to note that this does not mean a category is less important than another.

In term of costing, policy instruments and technological applications can be considered as a higher costing efforts compared to capacity building and guidelines development. Technological application requires huge financial injection in new installations and consistent maintenances. This may involve renovation or establishment of new spaces for storage and disposal purposes. Meanwhile, policy instruments utilize human and financial resources in designing and implementation process. Capacity building can be considered as a lower cost initiative and can be conducted through continuous trainings and awareness raising initiatives. This is similar with the development of guidelines and procedures which can incur lesser cost due to the readily available sources shared by various agencies including UNEP and WHO for adoption.

From the perspective of possible impacts, policy instruments and guidelines development have higher potential of impacts than technological applications and capacity building. Policy instruments are top bottom initiatives where decisions will trickle down to the practitioner at the ground level and create changes in the system. Another category with a potential high impact is the guidelines development. Efforts in guidelines development had been spearheaded by various international, regional and local agencies. Adopting these guidelines with or without personalization will bring considerable changes to the whole mercury management practices in a facility. From the four mentioned categories, technological application and capacity building is considered relatively lower in potential impacts. Technologies do provide benefits to the system but this is in specific areas like waste disposal. It does not cover the entirety of the mercury management system and it is influenced by the type of technologies utilized. Meanwhile capacity building is important however it depends on the effectiveness and limited to only those who attended the activities. The versatility of all these components in term of cost and impact gives flexibility for adopting the right measures according to the need and available resources. However, it must be noted that all these categories are equally important and shall be strengthened together in establishing a mercury-free medical facility.

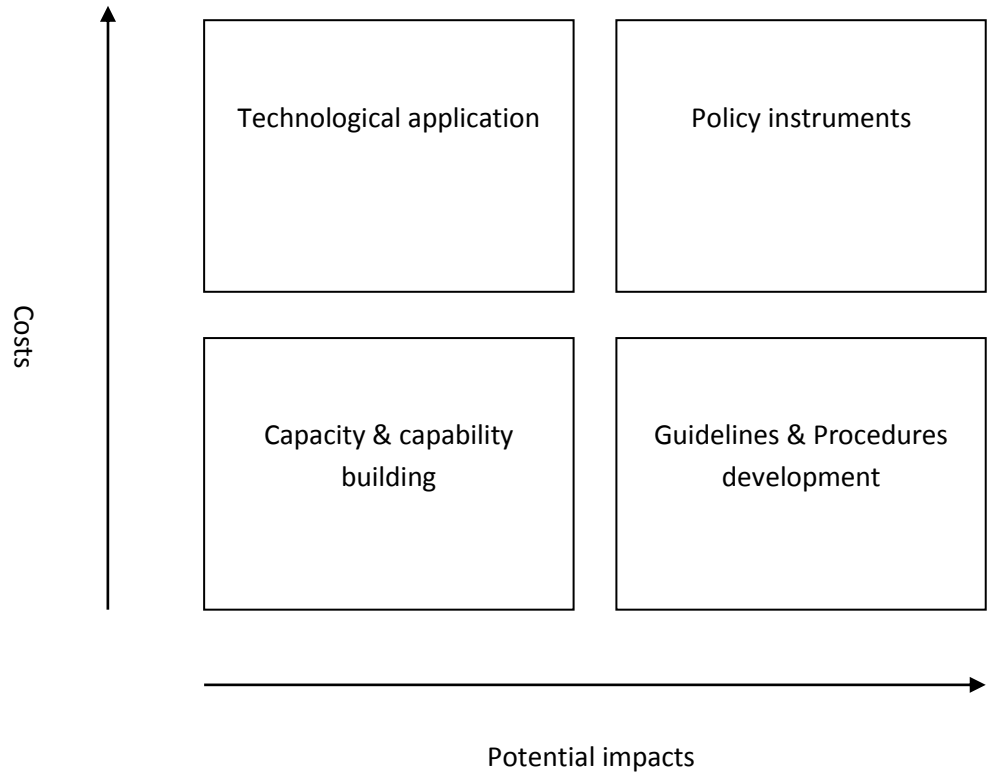

Figure 2. Relationship of practice categories with costs and possible impacts

CONCLUSION

Managing mercury-added products is a challenging task in mercury management through Minamata Convention on Mercury. The continuous demand and supply of mercury requires dramatic changes and this is intended to be achieved through phase out dates and measures in the convention. These can be achieved through programmes on governance, technical and trade activities conducted by the Parties. However, developing countries will be facing significant challenges particularly in funding, capacity, technology, know-how knowledge and necessary governance framework. Developing countries are acknowledged as important block in determining the success of the convention and therefore funding, knowledge and technical assistance will be a boost for the convention's success.

Experiences from medical industry in mercury management can shed more information in determining the suitable approaches. Adopting the life cycle approach, the mercury management in medical facility is best to be broken into several areas such as use, inputs, storage, application, incidents, disposals and monitoring. Each area has recommended practices by various international agencies and bodies to improve the mercury management. Upon closer observation, these practices can be grouped into four main categories namely technology application, policy instruments, capacity building and guidelines development, with unique relationship with cost and possible impacts.

Costs and possible impacts are two most important characteristics in considering the right measures to be implemented. Technology application and policy instruments will be more costly than guidelines development and capacity building. However, policy instruments and guideline development will give higher possible impacts. All these categories are important in mercury management however this relationship will give flexibility in planning for mercury-added products management according to the available resources while maximizing possible impacts. This will be helpful for developing countries in improving their overall mercury management specifically in the mercury-added products agenda.

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