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Journal

American Journal of Infection Control, 48(7)

ISSN

0196-6553

Authors

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Publication Date

2020-07-01

DOI

10.1016/j.ajic.2019.12.003

Peer reviewed

HHS Public Access

Author manuscript

Am J Infect Control. Author manuscript; available in PMC 2021 July 01.

Published in final edited form as:

Am J Infect Control. 2020 July ; 48(7): 751–756. doi:10.1016/j.ajic.2019.12.003.

Using Bottleneck Analysis to Examine the Implementation of Standard Precautions in Hospitals

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Abstract

Background—Service providers are often inadequately compliant with standard precaution protocols. This study used bottleneck analysis to identify the weakest link in standard precaution implementation and its associated challenges in hospitals.

Methods—Bottleneck analysis was conducted in 12 hospitals in Fujian Province, China. In each hospital, a focus group was organized among the key informants to illustrate the sequential steps of standard precaution implementation graphically. The level of difficulty and the specific challenges associated with each step were discussed.

Results—The sequential activities of standard precaution implementation generally start with making budget for personal protection equipment (PPE), followed by procurement, storage/inventory, in-hospital distribution, in-department distribution, usage/monitoring, and recycling of PPE. Service providers' improper use of PPE was the primary bottleneck. The reasons for improper use of PPE included high workload, time constraints, the sense of wearing PPE would interfere with clinical judgment, and various misconceptions. Making financial planning, recycling, and procurement of PPE were the secondary bottlenecks.

Conclusions—Bottleneck analysis is useful to illustrate workflow in healthcare systems and pinpoint constraints in standard precaution implementation. Institutional changes, including targeted provider training, adjustment of providers' workloads, and allocation of budget, are suggested strategies to address the identified bottlenecks in standard precaution.

Keywords

Standard precaution; hospital; service provider; implementation science

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Declaration of Interest: All authors have no conflict declared

INTRODUCTION

Health service providers are at risk for occupational infection of bloodborne pathogens.[1] Universal precautions are recommended by the CDC in 1985 as necessary safety procedures to protect service providers from needle stick transmission of HBV, HCV, and HIV.[2,3] The universal precaution guidelines were later updated, referred to as standard precaution, which is based on the principle that all blood, body fluids, secretions, excretions except sweat, nonintact skin, and mucous membranes may contain transmissible infectious agents.[4] The guidelines recommend service providers to ensure hand hygiene, use personal protective equipment (PPE; such as gloves and masks), and maintain sharps safety for all patients irrespective of their disease status.[5] Standard precaution is also mandatory with the passage of the Occupational Safety and Health Administration to prevent spreading infections among patients.[6]

Despite these guidelines, service providers' adherence to standard precaution is far below recommendation in both developing and developed countries. In a large observational study of emergency room service providers in the U.S., glove-wearing was observed in only 57% of the providers, and the hand-washing rate was as low as 28%.[7] A cross-sectional study conducted in Ethiopia reported that the proportion of service providers who always comply with standard precaution was only 12%.[8] The situation in China is also unsatisfactory, as a study in Beijing indicated that only less than half of the service providers were aware of the standard precaution guidelines or had ever received training on related knowledge.[9] The non-compliance to standard precaution guidelines results in negative consequences, including an increased incidence of occupational exposures/injuries of providers, as well as hospital infections of patients.[10] Moreover, lack of standard precaution training, knowledge, and adherence were found to be contributing to service providers' stigma to and avoidance intent to provide services to patients living with (or at risk of) HIV in their medical practice.[11]

Appropriate standard precaution compliance requires a set of complex procedures, from hospital-level planning, policy enforcement, and service providers' individual practice. Accordingly, there are multifaceted and multilevel factors associated with service providers' suboptimal compliance with standard precaution guidelines. For example, providers' sociodemographic and working experience were found to be associated with compliance with standard precautions.[12] Moreover, lack of training and regular monitoring were cited as reasons for providers' forgetfulness and uncomfortableness using PPE when performing clinical procedures.[13–15] Issues in hospital management, such as unavailability of material resources, distance to obtain necessary PPE, and time pressure, are also contributing to omitting standard precautions in situations in which it is indicated.[8,13–17] However, most studies regarding standard precautions have focused on a single perspective, typically around service providers' individual knowledge, perception, and behaviors.[18,19] The overall workflow of implementing standard precaution guidelines in hospitals, its constraints, and the associated root cause of constraints have received inadequate attention. In this context, the present study took a holistic approach to analyze the workflow of standard precaution implementation in hospital systems in China. Specific efforts were made to identify the bottlenecks (the weakest links where the workflow is constrained) in the pathway to

fulfilling standard precaution. The analytical approach and findings can shed light on designing targeted strategies to improve the enforcement of the internationally recognized standard precaution guidelines in healthcare systems.

METHODS

Study Design and Participating Hospitals

Bottleneck analysis is a step-wise approach to identify constraints hampering a health system from achieving the desired impact of an intervention, which in this study is standard precautions.[2022] The approach starts with depicting the process steps from start to finish, determine a target value (e.g., throughput rate, waiting time, difficulty level) for each process step, identify process steps where workflow is constrained, and find/address the root causes of those constraints. In this study, bottleneck analysis was conducted in 12 hospitals in Fujian Province of China during August 2016 and June 2017. The hospitals were selected using a stratified sampling strategy. We first obtained a list of all public hospitals in the province, city, and county levels in the province. Two provincial-level hospitals, four city-level hospitals, and six county-level hospitals were randomly selected using a random number table. Township and village level hospitals/clinics were excluded from the study because their scale and resources were too limited to conduct a bottleneck analysis. Private hospitals were excluded from the study due to connection discouragements.

Key Informant Identification and Recruitment

An initial step of the bottleneck analysis was to identify key informants in standard precaution implementation in each participating hospital. The investigator first approached the hospital directors/executive directors and sought their opinion regarding the persons who had the best knowledge/experience on standard precautions in their hospitals. The hospital directors were asked to recommend about ten people as standard precaution procedures key informants. These key informants included staff from procurement department, nosocomial infection control department, warehouse, recycling department, nursing department, as well as service provider representatives. Once the key informants were identified, the field staff approached them to start the recruitment. The field staff followed a standardized script to disclose all study procedures, and to ensure that all ethical issues and study procedures were reviewed. The key informants had to be 18 years or older and working in one of the selected hospitals to participate. It was emphasized that participation in the study was completely voluntary, the research was not part of their job responsibility, and their decision to participate would not affect their employment in any way. The study received ethical approvals from the Institutional Review Boards in the participating agencies in the U.S. and China.

A total of 108 key informants were recruited from the 12 hospitals (the number of informants in each hospital ranged from 8 to 11). The characteristics of the key informants are summarized in Table 1. The persons working in county-level hospitals accounted for approximately half of the sample (n=53; 49.1%). About two thirds (n=66; 61.1%) were female with an average age of 44.2 (SD=8.1) years. The majority (n=69; 63.9%) of the key informants had an undergraduate or higher degree. Approximately one third (n=39; 36.1%)

were working in clinical departments, which included departments of internal medicine, departments of surgery, departments of obstetrics and gynecology, departments of pediatrics, departments of dermatology, departments of infectious diseases, and emergency room. At the time of the study, 47 (43.5%) of the key informants were hospital administrators, including hospital directors, deputy directors, department directors, or department deputy directors. Other participants were doctors (n=20; 18.5%), nurses (n=22; 20.4%), technicians (n=6; 5.6%), and administrative staff (n=13; 12.0%).

Data Collection

One focus group was organized among all key informants in each hospital. The focus groups were conducted in private conference rooms in the participating hospitals. Each lasted for approximately 60 minutes. The discussion was moderated by a facilitator who had completed training in qualitative research and process analysis. The facilitator guided the key informants to define the discrete steps that the standard precaution supplies are achieved, distributed, and used in their hospital. The informants were encouraged to give as much details as possible. The steps were linked in sequential order, and an assistant facilitator drew the workflow diagram on a whiteboard. The diagram was shown to the informants to ensure correctness and comprehensiveness of the steps. Then the facilitator guided the informants to inspect the workflow diagram by identifying responsible parties of each step. In addition, all informants jointly rate the difficulty level of implementing each step using a 0–5 scale (0 as not difficult at all and 5 as very difficult). Open-ended comments regarding the specific challenges to perform the tasks in each step and suggestions for improvement were also solicited from the informants. The discussions were audiotaped using a digital voice recorder with the informants' consent. The informants received 100 RMB (approximately 16 USD) for participating in the focus groups.

Data Analysis

After all the focus group discussions, a final standard precaution implementation workflow diagram was developed by combining all of the diagrams generated from the 12 hospitals. The focus group facilitators reviewed the combined diagram and confirmed accuracy and completeness. The audiotapes of the discussions were transcribed verbatim into Microsoft Word documents. The data analysis was guided by the Grounded theory methodology to attain an understanding of the overall process of standard precaution implementation, perceived challenges associated with each step, and potential strategies for improvement.[23] The qualitative data analysis was performed using Atlas.ti (http://www.atlasti.com/index.html). We first developed a set of priori codes based on the focus group guide. The priori code list was then applied to the focus group transcripts and modified based on the emerged themes throughout the coding procedure. Themes relevant to the research questions were extracted from the data. Typical and informative answers were quoted in the Results section.

RESULTS

Overall Process of Standard Precaution Implementation

Although the details of standard precaution implementation varied across hospitals, the basic procedures could be summarized into seven steps, as illustrated in Figure 1: 1) the initial step is budgeting for PPE, which is performed annually in each hospital by the nosocomial infection control department and warehouse. The amount of PPE needed in the upcoming year is estimated based on the consumption in the previous year and adjusted by the increment in the estimated patient number in the upcoming year; 2) once the hospital director approves the budget, procurement departments are in charge of purchasing the supplies from contracted vendors. The frequency of purchasing differs from hospital to hospital (from biweekly to bimonthly) and also varies by the types of protective materials; 3) once the purchased PPE arrive the hospital, they are firstly made an inventory and temporarily stored in a centralized warehouses or equipment room in the hospital. This step is performed by the equipment department; 4) the fourth step is to distribute the PPE to the clinical departments and laboratories. Usually the head nurses are monitoring PPE stock in each department. Once the supply stock is below a certain amount, head nurses submit a requisition form to the centralized warehouse to request a material replenish. Most hospitals in the study had an internal computerized system to file the request, and refills are distributed to the departments either on a weekly basis or as needed; 5) once the PPE arrive each department, they are stored in a department-specific sub-depot, which is commonly located near the sterilizing room or the doctor's office. The providers individually obtain PPE when needed; 6) the sixth step is providers' utilization of PPE. The providers choose to use PPE when they see fit. Their compliance to standard precaution policy is supervised and monitored by the nursing department and the nosocomial infection control department, who perform regular and random checks of providers' protective behaviors at work. These two departments are also responsible for conducting standard precaution training for new employees and booster training in times of policy change or disease epidemic, and 7) the last step, recycling of used PPE, are usually handled by contracted outsourcing companies. The hospital cleaners collect medical wastes from each department and store them in a dedicated spot for the contracted recycling company to pick up on a regular basis. The frequency of waste collection ranges from daily to weekly, depending on the scale of the hospital.

Primary Bottleneck of the Standard Precaution Implementation

Step 6 (providers' utilization of PPE) was the single step received the highest difficulty grading **(4.5)** along the whole process of standard precaution implementation. Common incorrect operations reported by the informants included not changing gloves between patients if no visible contamination, wearing gloves only when the patients were seemingly to have contagious diseases, and using hand sanitizer as a replacement for gloves. In accordance with the high difficulty level rating, most perceived challenges were reported around the providers' utilization of PPE, which are summarized below

Firstly, many provider participants indicated that they were unclear about the standard precaution-related policy, particularly about the circumstances to use of wear protective eyewear or garments. Although all hospitals have organized or nosocomial infection-related

training, service providers often tended to skip such training because of their busy working schedules.

> "*When using a phlegm-sucker, there is a chance of splashing. But very few doctors are aware of the risks, so they usually don't wear goggles*." ---A nursing department staff in a county-level hospital

A second major barrier was the deeply-rooted virtue of thrift in Chinese culture. Several doctors from county hospitals mentioned that they would be reprimanded by directors or head nurses if they changed gloves and masks too frequently. It was believed, especially among senior providers, that using one pair of gloves for each patient was a wasteful behavior.

> "*We are reluctant to throw the disposable masks away after one time use because they are still usable next time. We have some disposable masks of good quality stored in our department, but the head nurse told us to save a few for unexpected epidemics*." ---An infectious disease doctor in a provincial-level hospital

Providers' workload also hindered their compliance with standard precaution protocols. Some providers saw hundreds of patients in a day, so they did not have sufficient time to change gloves in between. In case of emergency, providers also had little time to put on personal protective equipment.

> "*Every morning, I have to draw blood from more than one hundred patients. People are lining up and watching you. If you change gloves after every patient, they would complain that you are wasting their time*." ---A laboratory technician in a county-level hospital.

Fourth, unaccustomedness was frequently cited by the provider participants as a reason for not using PPE. A number of providers mentioned that gloves decrease their dexterity when performing medical procedures. Provider participants also complained about the poor quality of PPE. For example, the goggles were reported to be heavy and unfit to the face, so that providers' vision was affected. Hence goggles were rarely used in their hospitals.

> *"It is hard to perform vascular puncture with gloves on. Sometimes our providers need to try many times. It adds unnecessary suffering to patients, let along burdens to our providers. That is why we don't encourage wearing gloves for every patienta unless the patient is known to have syphilis, HIV, or other transmittable diseases*." ---A head nurse in a city-level hospital

Last but not least, there was a perception among service providers that wearing protective equipment was an act of disrespect for patients. Several provider participants anticipated that their patients might experience psychological distress, anxiety, or panic when they see providers wearing masks, garments, and gloves, because they may interpret it as a sign of current disease outbreak.

> *"Imaging when we are seeing a TB patient who is known to be HIV-positive, if you suddenly wear gloves and masks, it is like telling everybody else he has some infectious diseases. It is a breach of patients' confidentiality."*--- An internist in a county-level hospital

Secondary Bottlenecks of the Standard Precaution Implementation

Steps 1, 7, and **2** also received relatively high difficulty rating (2.8, 2.7, and 2.3, respectively). For **Step 1** (financial planning), organizational financial issues played a critical role in the inadequate budget allocation to standard precaution. Financial difficulties were particularly pronounced in lower-level hospitals. Two city hospitals and one country hospital indicated that they sometimes had to sacrifice the quality of PPE in order to cut down the cost. Hospital stakeholders also restricted the usage of PPE for the economic benefit of the hospital. The informants called for the government to deploy financial subsidies for PPE.

> "*Our hospital has an internal cost accounting system, and the usage of the consumables are closely monitored. We have to treat a large number of patients every day. One pair of gloves for each patient is not realistic*." ---A nursing department staff in a county-level hospital

For **Step 7** (recycling), both service providers and supporting staff lacked training in the classification and disposal of medical waste. Recapping needles was still a common practice among service providers because sharp containers were expensive and not widely accessible. Employees in the outsource companies who handled of medical waste were highly mobile, which made systematic professional training unfeasible. Used sharp substances were often improperly disposed or even mixed with municipal waste. Needle stick injuries were commonly reported among hospital administrative workers, such as scavengers, janitors, and caregivers. Strengthened training and supervision for both service providers and administrative workers were suggested by the informants.

> *"The staff of recycling companies are less educated and hard to communicate. Although we have trained them to wear gloves when handling medical waste, they still don't do so for convenience reasons. Sometimes our providers have already categorized the used PPE, but the recycling company staff just mixed everything together."*---A head nurse in a provincial-level hospital

For **Step 2** (procurement), most hospitals indicated little difficulties in terms of PPE purchasing in usual times. However, in the case of public health emergencies (such as SARS in 2003 and the H7N9 outbreak in 2013), the hospitals had to deal with a shortage of supply and a soaring price of PPE. Informants from all levels of hospitals complained that they had seen PPE with substandard quality.

> *"Our gloves are usually thinner than the ones doctors get. They break easily. Actually, we deserve PPE with better quality because our lab technicians are facing the highest risk of occupational exposure to contaminated body fluid."*---A lab technician in a city-level hospital

Other Challenges

Although **Steps 3, 4**, and **5** received low difficulty ratings (0.8, 0.9, and 0.8, respectively), several challenges associated with these steps were brought up by the informants. For **Step 3** (inventory), some hospitals had very limited storage space that could only keep ten

protective garments at a time. Concerns of overstock and expiration were also mentioned as reasons for having insufficient storage of PPE.

The informants perceived little difficulties in **Step 4 (**in-hospital distribution). There were a couple of informants, however, implied that requesting too many consumables would impact their department's performance evaluation. Garments and goggles were rarely used, so they were not routinely prepared in the department. They could be requested from the equipment department in case of emergencies.

The most significant barrier for **Step 5 (**in-department distribution) was that the PPE were not always available at every ward so that a substantial proportion of providers chose to omit using protection in order to save time. Some informants suggested that that PPE should be made available either in every ward/examination room or just carried in the utility cart with other medicine and disinfection supplies.

DISCUSSION

Implementation of standard precautions in hospital settings is a complex and multistage process that involves multiple handoffs among hospital administrators, service providers, and supporting staff. Any setback in infrastructure, workforce, financial resources, logistics, or governance would hamper the achievement of the desired protective effects of standard precautions. This study demonstrated the use of bottleneck analysis to investigate the standard precaution implementation procedures in the healthcare system. This simple process mapping exercise presented in this paper was a starting point to recognize the most significant gaps in compliance with standard precaution guidelines. The involvement of all related parties in round-table discussions could prompt the agreement that both environment and individual factors have a role in promoting standard precaution adherence. Such a consensus would bring force a collaborative problem-solving endeavor. This analytical approach can also be applied to other health quality improvement issues that involve multiple sectors, for instance, the delivery of maternal and newborn care services.[20,24] Hospital administrators are recommended to perform this exercise in cycles to self-examine the process of implementing a clinical procedure, identify system bottlenecks, devise specific strategies to remove the bottlenecks, and reanalyze the implementation process.

The service providers' failure to wear PPE consistently and correctly was identified as the leading barrier (bottleneck) in the implementation of standard precaution protocols in hospital systems. A variety of incorrect practices and the correlated misconceptions about standard precautions were identified in the study. The finding pinpointed the urgent need to train service providers on infection control and standard precaution knowledge on an ongoing basis. At the same, staff supervision system should be in place in every hospital to ensure safe behaviors of service providers. Although providers reported that wearing protective equipment was uncomfortable and reduced their dexterity, the habitual aspect can be corrected by strict policy enforcement and intensive training of service providers.[13,19,25] Future standard precaution training should not only correct fallacies in practice, but also counter the misconceptions of standard precautions as being disrespectful for patients.

Nonetheless, individual providers should not be blamed for their suboptimal compliance in standard precautions, because the root causes of their non-compliance were intertwined with other structural factors, and hence could only be tackled by structural level intervention strategies. Based on the study findings, we hereby suggest there structural changes to hospital administrators and policymakers: first, financial constraint plays an important role in providers' hesitation to use PPE. The organizational culture often lay a narrow focus on clinical performance and its correlated financial profit while ignoring long-term consequences of standard precaution non-adherence.[26] It is important for hospital authorities to recognize the cost-benefit of standard precaution reinforcement and the potential risk of losing welfare if sufficient PPE is not guaranteed.[27] Service providers' occupational safety and nosocomial infection control should not be compromised, even under circumstances of budget limitation. Second, given the high workload of service providers in China, wearing and changing protective wear between patients is considered time-consuming and interfering with providers' duties to treat patients in a timely manner. In addition, the time limits also hinder providers' participation in standard precaution training. Hospital administrators should devise strategies to avoid patient overcrowding and set realistic workloads for service providers. Third, lack of immediate accessibility of PPE at the point of need has been identified as a major withholder of standard precaution compliance both in this study and previous studies.[28] The within-department PPE storage system should be redesigned to make PPE supplies visible and readily accessible in each ward to reduce service providers' unnecessary time and effort to obtain PPE.

Other critical issues identified from this study is the mismanagement of used PPE in the hospitals. Within the 12 participating hospitals of the study, wide variations exist in the practices of waste segregation, collection, storage, transportation, and disposal. In the absence of training and strict reinforcement of medical waste management guidelines, clinical providers, as well as hospital sanitary workers and other supporting staff's occupational safety is jeopardized. Although the Chinese government has promulgated medical waste management regulations,[29] the actual implementation of these rules is questionable. This is a serious concern without adequate awareness not only in China but also in many developing countries.[30] Standardized training and management of medical waste are urgently warranted.

Several limitations of this study should be noted. First, the study was conducted in one province of China. The findings may not be generalizable to other areas where different economic situations could impact standard precaution implementation in hospitals. Second, the focus group participants were comprised of a number of constituencies, including hospital administrators, service providers, and administrative staff. Some participants may not have expressed their honest opinions due to the power imbalance and the influences from the others. Third, the difficulty rating of the implementation steps could be participants' subjective perception, which could not be validated by hospital administration documents.

In conclusion, bottleneck analysis used has important implications for promoting standard precautions in hospital systems. The frontline service providers' compliance was found to be the weakest link in the standard precaution implementation in hospitals in China. Efforts should be made to address this identified bottleneck and ensure the benefit of standard

precaution. The study broached several key recommendations for service providers training, as well as PPE supply storage, distribution, and recycling, to make standard precaution procedures an integral part of the medical practice. Although the study was conducted in China, the methodology used could be applied to health service improvement in other counties.

Acknowledgments

This study was supported by the National Institute of Mental Health (NIMH) Grant K01MH102147. We would like to thank the project team members in the Fujian Provincial Center for Disease Control and Prevention for their contributions to this study.

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HIGHLIGHT

- Bottleneck analysis was used to examine hospitals' standard precaution implementation
- Service providers' improper use of protection equipment was the primary bottleneck
- High workload and misperceptions contributed to incompliance of standard precaution
- Secondary bottlenecks included difficulties in finance, recycling, and procurement

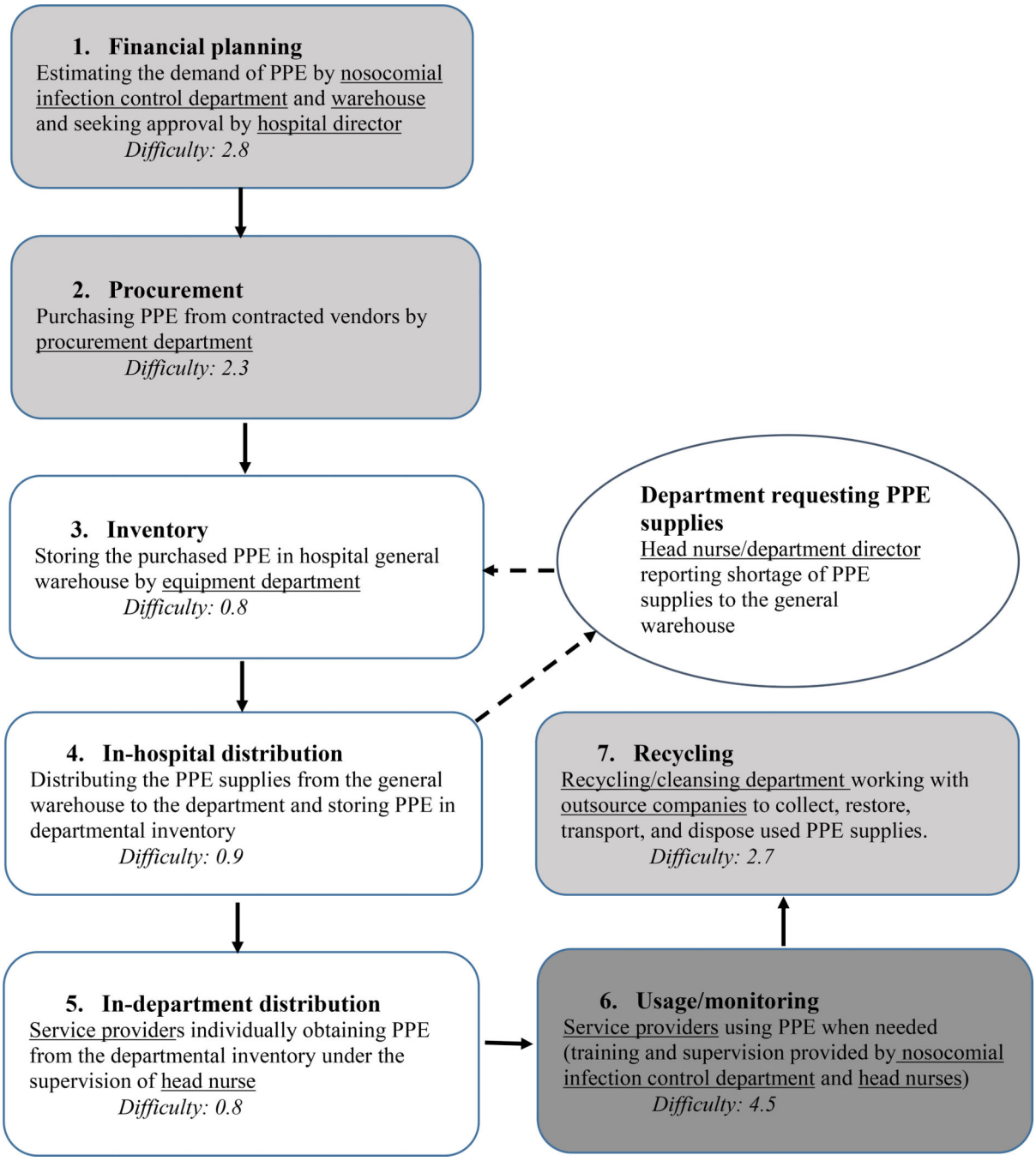

Figure 1.
Procedures of Implementing Standard Precautions in Hospitals

Table 1.

Characteristics of the Standard Precaution Key Informants (N=108)

	Number	Percentage
Hospital level		
Provincial-level	19	17.6
City-level	36	33.3
County-level	53	49.1
Gender		
Male	42	38.9
Female	66	61.1
Age		
Less than 40 years	30	27.8
40–49 years	48	44.4
50 years and above	30	27.8
Education		
Graduated degree	5	4.6
Undergraduate degree	64	59.3
Associated degree	19	17.6
Technical school/senior high graduated Department	20	18.5
Department		
Clinical departments	39	36.1
Nursing department	11	10.2
Laboratory and pharmacy	13	12.0
Nosocomial infection control department	15	13.9
Purchasing, equipment, recycling, and cleansing departments	18	16.7
Supportive service department Position/title	12	11.1
Position/title		
Hospital director/deputy director	3	2.8
Department director/deputy director	44	40.7
Doctor/public health doctor	20	18.5
Nurse	22	20.4
Technician	6	5.6
Staff	13	12.0