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Healthcare infrastructure capacity to respond to severe acute respiratory infection (SARI) and sepsis in Vietnam: A low-middle income country

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ABSTRACT

Purpose: This study investigated the availability of relevant structural and human resources needed for the clinical management of patients with severe acute respiratory infections and sepsis in critical care units in Vietnam. Material and methods: A questionnaire survey was conducted by purposive sampling of 128 hospitals (36% of total hospitals in surveyed provinces), including 25 provincial and 103 district level hospitals, from 20 provinces in Vietnam. Data on availability of hospital characteristics, structural resources and health care workers was then analyzed.

Results: Most hospitals (>80%) reported having 60% of the relevant structural resources. Significant differences were observed between provincial hospitals compared to district hospitals in regards to availability of central oxygen piping system (78.3% vs 38.7%, p = 0.001) mechanical ventilation (100.0% vs 73.6%, p = 0.001), mobile x-rays (80.0% vs 29.8%, p < 0.001), carbapenem antibiotic (73.9% vs 17.4%, p < 0.001) and norepinephrine (95.8% vs 56.3%, p < 0.001). There was a limited availability of arterial blood gas analyzers (13.7%), oseltamivir (42.2%) and N95 respirators (54.6%) across all hospitals surveyed.

Conclusions: The limited availability of relevant structural and human resources in critical care units across Vietnam makes the implementation of quality critical care to patients with SARI and sepsis, according international guidelines, not universally possible.

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1. Introduction

In recent years, emerging infectious diseases have appeared across developing countries in Africa and Asia, raising global health security concerns [1]. Severe acute respiratory infections and sepsis, as well as antibiotic resistance are recognized as major threats to health systems of developing countries and are leading causes of death [2]. Hospital mortality from sepsis, the major intermediate pathway to death from all severe infections, has been found to increase as national income decreases suggesting intensive care unit (ICU) organization has an important effect on risk of death [3]. It is imperative to address this gap and find solutions to strengthen critical care service delivery in these resource-limited settings.

A number of studies have shown a significant shortage of both healthcare facilities and human resources among developing countries [4-6]. In South East Asia, there was a considerable demand for hospital beds, medications, doctors and nurses to cope with pandemic influenza [5]. Most recently, international collaborations are addressing these gaps by developing modified guidelines and frameworks for intensive care units that can be used for health system planning and evaluation of ICU capacity [7,8].

Vietnam is a lower middle-income country, ranked 13th in the world and 3rd in Southeast Asia by population with 91 million people [9]. Vietnam is also a hotspot for emerging infectious diseases in Southeast Asia. It was affected by SARS-CoV outbreak in 2003 with a total of 63 cases and 5 deaths but became the first country to control the outbreak 40 days after its first case detection [10]. Since 2002, avian influenza A(H5N1) has circulated in the country with a total 127 confirmed cases and 64 deaths, ranking 3rd among countries with the highest number of human cases and fatal cases (updated by 2016) [11]. Additionally, severe dengue, Streptococcus suis infection and the increase in antibiotic resistance are other major causes of sepsis in critical care units across Vietnam [12-14]. Because of Vietnam’s regional prominence (size, population) and experiences with clinical management of
emerging infections, it is in an opportune position to help understand the gaps (i.e. structural, processes, outcomes) and develop solutions (i.e. health system planning, modified guidelines, intervention trials, quality improvement) to improve the critical care management of patients with SARI and sepsis.

The first step, and the aim of this study, was to conduct a survey to describe the hospital characteristics, structural resources and human work force in critical care units at the provincial and district hospital levels in Vietnam. The information is important to guide health system planning and priority setting, to determine the allocation of resources, and to the development of appropriate, adapted national clinical management guidelines and training programs to better care for patients with SARI and sepsis on an everyday basis and during outbreak or pandemic situations of emerging infectious disease.

2. Material and methods

2.1. Survey setting

The Vietnam healthcare system is structured in four technical levels corresponding to government administration system, including central level, provincial/municipal, district and communes [15]. Public hospitals are graded in 5 categories (special rank hospitals and levels from 1 to 4) on indicators of (1) hospital size, scope and content of activities, (2) division of labor and quality of human resources, (3) professional capacity and quality of work performance and (4) infrastructure and equipment [16]. In general, the central level includes special rank hospitals and grade 1 hospitals which under or appointed by the Ministry of Health. Provincial/municipal level includes some grade 2 hospitals that are under the Ministry of Health and some grade 1–2 hospitals under the provincial departments of health. District level is under provincial departments of health, includes grade 3–4 hospitals, general/specialized clinics, midwifery-led clinics and district health centers in places without district hospitals. Communal level includes commune health stations, family medicine clinics and workplace clinics.

As of June 2014, Vietnam had 492 public provincial hospitals (including general hospitals and specialized hospitals in difference disciplines) in 64 provinces and 620 general district hospitals in 708 districts or equivalent throughout the country [17]. As of 2015, the total number of patient beds in the country was 306,100 (including 232,900 hospital beds) with 73,800 doctors, 58,400 physicians assistants and 102,700 nurses [18].

According to Vietnam government’s regulations [16], an emergency department (ED) is a medical treatment facility which admits and treats all patients with emergency conditions referred to the hospital. Its function is to assess, triage and provide appropriate management by priority level of emergency until the patient is no longer in a serious condition and then within 48 h must transfer the patient to an Intensive care unit (ICU) or an appropriate medical ward when patient’s status allow. An ICU is a clinical department responsible for providing continuous critical care for patients who are transferred from an ED or clinical wards of the hospital. Because most district hospitals cannot establish separated ED and ICU, critical care unit (CCU) is referred to ICU or ED-ICU. Critical care units are the units where patients with SARI and sepsis are cared for in Vietnam and thus the scope of this survey.

2.2. Hospital selection

From June to July 2015, a survey was implemented among 20/63 (31.7%) provinces in Vietnam. Theses provinces were selected purposely based on the consideration of potential points of entry of avian influenza A(H7N9) viruses from China and avian influenza A(H5N1) viruses from Cambodia in poultry at the time of the survey initiation. Sixteen out of 40 provinces that reported highest burden of human avian influenza A(H5N1) cases (accounted for 64.5% or 80/124 laboratory-confirmed cases) were included. Four of the bordering provinces were on alert to avian influenza entering among poultry (Fig. 1). In each selected province, the point of contact from provincial department of health sent survey forms to provincial and district hospitals in their catchment areas and only responsive hospitals (convenient sample) with critical care units were included in this analysis.

2.3. Questionnaire development

The survey form was designed to capture hospital characteristics, personnel information and availability of relevant equipment, supplies and medicines in the critical care units. Data was collected from 2 sources: (1) data extraction from the official hospitals statistics reports in 2014 and (2) self-administered questionnaire. The hospitals statistics are official regular reports at 3, 6, 9 and 12 months required by the Ministry of Health for governmental hospitals and validated by hospital
internal quality control mechanisms. Data extraction forms included information on numbers of hospital and CCU admission, numbers of planned beds, average lengths of hospital and CCU stay for in-patients and numbers of doctors and nurses. For the self-administered questionnaire, item generation was initially developed by 2 investigators who are intensivists working in tertiary referral ICUs in Vietnam and the United States through literature review and group discussion among peer ICU and ID physicians during the Severe Acute Respiratory Infection (SARI) Critical Care Training conducted in Vietnam in May 2015. Refinement and item reduction of the list of supplies, equipment and medicines was pragmatically generated through reviews of national guideline on management of H5N1 influenza (last updated on 2003), H1N1 influenza (last updated on 2011) and Middle East respiratory syndrome coronavirus (MERS-CoV) (last updated on 2015). With the consensus, the following domains were included: infection prevention and control, cardiorespiratory support and antimicrobials. The questionnaire was piloted for relevance and flow and further revised with inputs from 6 doctors working in ICUs and emergency departments in 2 provincial hospitals in Hanoi, Vietnam, which were not included in the final analysis. The face validity was evaluated for the interpretation, appropriateness and logical sequence of questions using the Vietnamese questionnaire. The questionnaire content validity was also evaluated for the essentiality of the questions. The final questionnaire was distributed by mail and the information in the questionnaire was completed by the head of CCUs at selected hospitals and kept confidential. The respondents’ answers were validated by the director board of the hospitals and returned to investigators for data entry and analysis.

2.4. Statistical analysis

Paper questionnaires were entered into an electronic database by single entry and re-checked by reviewing out range values in order to detect data errors. Statistical analysis was performed using STATA version 11 (STATA Corp., Texas, USA). Frequencies of all categorical data were calculated based on the number of completed questions and compared by using Chi square or Fisher’s Exact test, as appropriate. Continuous variables are calculated as median values with interquartile ranges (IQR) and the comparison between groups using the Mann Whitney U test or Kruskal-Wallis test, where appropriate. p-Values < 0.05 were considered to be statistically significant.

3. Results

This study collected data from 128/354 (36.2%) hospitals in the 20 pre-selected provinces and included 25 provincial level hospitals and 103 district hospitals with assigned CCUs.

3.1. Hospital characteristics

3.1.1. Provincial hospitals

The provincial hospitals served a median population of 1,020,597 (665,152–1,477,300) persons. The median number of CCU beds was 26 (17–33) accounting for 4% (3–5%) of total hospital beds while the proportions of CCU staff to hospital staff were 6% (4–8%) for doctors and 8% (6–10%) for nurses. The median (IQR) annual admission rate per a CCU bed it was 64.1 (42.5–144.5) and median length of stay was 6.0 (3.6–7.2) days. In 2014, there were 1482 (1043–2368) CCU admissions, accounting for 6% (3–9%) of total hospital admissions. See Table 1 for details.

3.1.2. District hospital

The district hospitals, as would be expected, served a significantly smaller population and geographic area than those of provincial level. The number of critical care beds at the district hospital levels varied, with 45% hospitals having 1–10 beds and 42%, having 11–20 and 14% having >20 beds. The number of critical care beds were not correlated with the size of the estimated population served or estimated serving area. However, there was a correlation between the number of hospital beds and the annual admission rates.

The median number of CCU beds was 12 (8–19) and accounted for 9% (5–12%) of total hospital beds, while the proportion of CCU staff to hospital staff was 10% (7–13%) for doctors and 12% (9–18%) for nurses. There was a significant difference in proportion of CCU bed to hospital bed and CCU staff to hospital staff between district and provincial hospitals as well as CCU staff per bed (Table 1). In 2014, there were 891 (461–1783) CCU admissions, accounting for 11% (6–22%) of total hospital admissions.

3.2. Equipment, supplies and medicine for hemodynamic and respiratory support

3.2.1. Provincial hospitals

Most provincial CCUs had the necessary supplies and equipment to provide critically ill adult and pediatric patients with basic respiratory and hemodynamic support (see Table 2 for details). Almost 50% of the relevant structural resources surveyed were available in all the provincial level hospitals. Though all provincial CCUs had ventilators, the median number of ventilators was 11 (6–16) per CCU, with a low ventilator to bed ratio at 0.40 (0.26–0.55). Slightly fewer CCUs had central oxygen systems (78.3%) and mobile chest film capacity (80.0%). Strikingly, points of care blood gas analyzer machines were very limited and only found in 39.1% of provincial hospitals whereas portable ultrasound (66.7%) and hemofiltration (63.2%) were more widely available.

3.2.2. District hospitals

Most district hospitals had some of the basic equipment to provide critically ill adult and pediatric patients with respiratory and hemodynamic support (see Table 2 for details). In contrast to the provincial level, only 5 (12.8%) of the structural resources surveyed were available at all the district hospitals. 73.6% of district hospitals had ventilators with significantly lower number of ventilators (median 1, IQR 0–2) and a very low ventilator-to-bed ratio when compared to provincial hospitals. Other equipment found to be significantly less available at the district hospital level included: central oxygen piping system (38.7%), mobile chest x ray (29.8%), central venous catheters (27.7%), norepinephrine (56.3%) and blood gas analysis machine (7.5%) (p values <0.001). Notably, bedside ultrasound was available in nearly one-half of the (47.7%) district hospitals, not significantly different from provincial hospitals (p = 0.100).

3.3. Availability of antimicrobial therapy

The availability to a sample of antimicrobials can be found in Table 3. Oseltamivir was very limited in its availability at both levels. The only significant difference between provincial and district hospitals was in the proportion of hospitals with access to carbapenem antibiotic.

3.4. Supplies for infection prevention and control

The availability of equipment to implement infection control and prevention measures can be found in Table 4. Nearly all had hand washing facilities, such as liquid soap (100.0%), access to sterile gloves (96.8%) and medical gloves (98.4%). However, shortages were seen at both levels in the availability of N95 particulate respirators (54.6%), medical goggles (56.7%) and gowns (reusable 62.1%, single use 50.0%). The only significant difference between provincial versus district level hospitals was in the proportion of hospitals with single-use gowns.

4. Discussion

We conducted a survey of 128 critical care units from 20 purposively selected provinces in Vietnam, and found that although some of the
essential structural and human resources were available at the sampled provincial and district level hospitals there were significant gaps. Only about 50% of the surveyed structural resources were available in all of the provincial hospitals, and just 13% available in all the district hospitals. However, most hospitals (>80%) did report having 60% of relevant resources. Workforce shortages were also reported. Due to these challenges, the surveyed hospitals in Vietnam were not able to consistently implement in their entirety national or international guidelines on SARI and sepsis management. Because emerging infectious diseases and sepsis are a threat to global health security and major cause of death [1], improving basic critical care service delivery in resource limited settings (like Vietnam) is necessary and urgent.

Since the SARS pandemic in Vietnam in 2003, hospitals have improved capacity in terms of hospital hygiene and infection control.

| Table 1 | Characteristics of sampled district critical care units. |
|---------|----------------------------------------------------------|
| All surveyed hospitals | Provincial hospitals | District hospitals | p-Values |
| N = 128 | N = 25 | N = 103 |
| **Hospital profiles (median[IQR])** | | | |
| Estimated serving area (km²)* | 366.9 (188.7–885.4) | 2508.3 (926–6384) | 267.7 (1647–8086) | – |
| Estimated served population | 140,428 (84099–229,297) | 1,020,397 (695152–1,477,300) | 123,775 (69506–162,900) | – |
| Number of planned hospital beds | 130 (90–180) | 500 (380–780) | 110 (90–150) | <0.001 |
| Number of actual beds | 162 (121–271) | 600 (460–921) | 146 (110–212) | <0.001 |
| Total of hospitalized patients in 2014 | 9957 (6398–14,309) | 36,926 (19637–48,391) | 8362 (5526–11,680) | <0.001 |
| Annual admission rate per hospital bed | 51.5 (44.7–60.6) | 48.1 (41.2–59.9) | 52.5 (45.7–61) | 0.240 |
| Length of stay (days) | 6.0 (5.3–6.8) | 7.0 (5.8–8.2) | 5.9 (5.2–6.8) | 0.390 |
| Number of doctors | 32 (18–50) | 132 (88–158) | 26 (16–26) | <0.001 |
| Number of nurses | 55 (35–88) | 290 (206–394) | 44 (33–71) | <0.001 |
| Number of doctors per actual bed | 0.15 (0.13–0.22) | 0.19 (0.14–0.25) | 0.15 (0.12–0.21) | 0.065 |
| Number of nurses per actual bed | 0.32 (0.25–0.42) | 0.43 (0.34–0.53) | 0.31 (0.24–0.40) | <0.001 |
| Hospital staffing ratio per bed | 0.49 (0.40–0.61) | 0.56 (0.49–0.84) | 0.46 (0.38–0.59) | 0.005 |

| Table 2 | Availability of supplies and equipment for management of respiratory distress and shock. |
|---------|----------------------------------------------------------|
| All surveyed CCUs | All surveyed provincial CCUs | All surveyed district CCUs | p-Values |
| N = 128 | N = 25 | N = 103 |
| **Nasal oxygen cannula** | | | |
| 82.9% (97/117) | 91.3% (21/23) | 80.9% (76/94) | 0.356 |
| Oxygen mask (adult) | 90.2% (111/123) | 100.0% (23/23) | 88.0% (88/100) | 0.120 |
| Oxygen mask (pediatric) | 84.3% (102/121) | 90.9% (20/22) | 82.8% (82/99) | 0.521 |
| Endotracheal tube (adult) | 97.6% (121/124) | 100.0% (24/24) | 97.0% (97/100) | 1.000 |
| Endotracheal tube (pediatric) | 87.6% (106/121) | 95.7% (22/23) | 85.7% (84/98) | 0.298 |
| A bag valve mask (adult) | 100.0% (124/124) | 100.0% (24/24) | 100.0% (100/100) | – |
| A bag valve mask (pediatric) | 96.8% (119/124) | 91.3% (21/23) | 98.0% (98/100) | 0.158 |
| Central oxygen piping system | 46.6% (54/116) | 78.3% (18/23) | 38.7% (36/93) | 0.001 |
| Oxygen cylinder | 86.0% (104/121) | 87.5% (21/24) | 85.6% (83/97) | 1.000 |
| Ventilator availability | 78.9% (86/109) | 100.0% (22/22) | 73.6% (64/88) | 0.003 |
| Number of ventilators | 1 (1–2) | 11 (6–16) | 1 (0–2) | <0.001 |
| Number of ventilator per actual bed | 0.10 (0.03–0.25) | 0.40 (0.26–0.55) | 0.08 (0.00–0.17) | <0.001 |
| Monitors | 95.9% (118/123) | 100.0% (24/24) | 95.0% (94/99) | 0.582 |
| Bedside pulse oximeter | 93.6% (116/124) | 100.0% (24/24) | 92.0% (92/100) | 0.352 |
| Suction machines | 100.0% (124/124) | 100.0% (24/24) | 100.0% (100/100) | – |
| Bedside ABC machines | 13.7% (16/117) | 39.1% (9/23) | 7.5% (7/94) | <0.001 |
| Hemofiltration | 13.4% (13/97) | 63.2% (12/19) | 1.3% (1/78) | <0.001 |
| Number of hemofiltration machines | 0 (0–0) | 1 (0–1) | 0 (0–0) | <0.001 |
| Bedside ultrasound machines | 51.8% (58/112) | 66.7% (16/24) | 47.7% (42/88) | 0.100 |
| Number of bedside ultrasound machines | 1 (1–2) | 1 (0–1) | 0 (0–1) | 0.003 |
| Mobile x-ray machine | 39.4% (41/104) | 80.0% (16/20) | 29.8% (25/84) | <0.001 |
| Dobutamine | 73.3% (88/120) | 100.0% (24/24) | 66.7% (64/96) | 0.001 |
| Dopamine | 91.9% (113/123) | 100.0% (24/24) | 89.9% (89/99) | 0.207 |
| Ephedrine | 100.0% (124/124) | 100.0% (24/24) | 100.0% (100/100) | – |
| Norepinephrine | 64.2% (77/120) | 95.8% (23/24) | 56.3% (54/96) | <0.001 |
| Intravenous infusion pumps | 86.3% (105/121) | 87.5% (21/24) | 85.7% (84/98) | 1.000 |
| Central venous catheters | 41.9% (49/117) | 100.0% (23/23) | 27.7% (26/94) | <0.001 |

* Data was retrieved from Provincial Statistical Yearbook (2012–2014) of surveyed provinces and The 2009 Vietnam Population and Housing Census.
Despite these efforts, the results of this study show that all components of personal protective equipment were not universally available. While hand hygiene materials, medical masks and sterile gloves were available at all hospitals, there were still gaps in the availability of eye protection, protective clothing and particulate respirators. Implementation of infection prevention and control measures is essential to prevent the spread of infection between patients and health care workers and when there is a lapse in consistent and correct personal protective equipment use there can be transmission [19]. During the SARS pandemic in Vietnam, cross-transmission between patients and health care workers caused five deaths [20], and similar nosocomial outbreaks were seen with MERS-coronavirus (CoV) in Saudi Arabia and South Korea [21]. The WHO recommends that when caring for all SARI patients with suspected influenza or other dangerous respiratory virus infection, that droplet precautions be used, and this indeed does seem locally feasible. But, the WHO also recommends the use of airborne precautions with particulate respirators when performing invasive procedures such as intubation [19]; and if human infection with avian influenza or MERS-CoV is suspected then the addition of contact precautions. Clearly, healthcare workers in Vietnam would not be able to fully protect themselves consistently thus placing themselves and other patients at risk. These results demand improvement of the supply chain of personal protective equipment to all hospitals in Vietnam.

Our study shows that the surveyed hospitals were not all reliably equipped with the essential equipment, supplies and medicines needed to manage the most severe manifestations of SARI and sepsis, such as shock and acute respiratory failure. Similar findings have been reported in many developing countries, in the fight against sepsis, outbreaks, pandemics and epidemics [5,22]. For example, at the provincial level, a patient with fluid refractory shock would be able to receive the 1st line vasopressor norepinephrine (strong recommendation from the Surviving Sepsis Campaign [23]) administered through a central venous catheter. However, this was not the case at the district hospital level, where noradrenaline and central venous catheters were not widely available. Our study also shows that the diagnosis of acute respiratory distress syndrome (ARDS) by the Berlin criteria was not feasible at either the provincial or district level hospitals because of the limited availability of blood gas analysis and mobile chest x-ray. This underscores the Lung Safe study that found that ARDS is under-recognized and under-treated globally [24] because its diagnosis in resource limited settings is much more difficult [25]. However, the Kigali-modification could be used as our study did find ultrasound to be available at both levels and near 100% availability of pulse oximetry. Vietnam could thus be an ideal setting to conduct a validation study of the Kigali-modified criteria. However, treatment of ARDS using lung protective ventilation strategy without blood gas analyzer would remain a challenge. More so at the district level, where there is limited availability of piped oxygen, ventilators and very low ventilator per bed ratios.

Administration of early, empiric, broad-spectrum antimicrobials for all likely pathogens is another strong recommendation of the Surviving sepsis campaign [23]. In a surveillance study of SARI in Vietnam, influenza was positive in 18% of SARI cases [26]. Our study shows that oseltamivir, the 1st line antiviral agent for treatment of severe influenza virus infection (WHO recommendation [27]), had limited availability at both district and provincial level hospitals. Again, raising the urgency to make this medicine more widely available. Our study also shows preliminary data on antibiotic availability, with major finding of limited carbapenem availability, especially at the district hospital level. Antimicrobial resistance has significantly increased globally and a study conducted in 15 tertiary and provincial ICUs across Vietnam reported a high hospital-acquired infections prevalence of 29.5%, with the most common pathogens being Acinetobacter baumannii, Pseudomonas aeruginosa, and Klebsiella pneumonia and carbapenem-resistant proportions of these Gram-negative bacteria were alarming at 89.2%, 55.7%, and 14.9% respectively [28]. These results raise urgency for a more detailed study on antibiotic availability and the need for appropriate antibiotics usage strategy that includes antibiotic stewardship and policies about infection prevention to control the increasing antibiotic resistance in resource limited settings with growing ICU capacity [29].

Our study also describes a “snap shot” picture of some organizational aspects of CCUs, and from our knowledge, the first paper to do such a national description in Vietnam. The CCUs were busy, with annual admission rates similar to a hospital bed, and accounting for 10% (5%–18%) of all hospital admission. In 2006, the WHO reported the health workforce capacity in South East Asia and other developing regions were still remarkably smaller than in developed regions (2.3 health workers per 1000 population in Africa, 4.3 in South East Asia compared to

Table 3

| Antibiotic classes | All surveyed CCUs N = 128 | All surveyed provincial CCUs N = 25 | All surveyed district CCUs N = 103 | p-Values |
|--------------------|--------------------------|------------------------------------|-----------------------------------|---------|
| Carbapenem         | 29.4% (32/109)           | 73.9% (17/23)                      | 17.4% (15/86)                     | 0.001   |
| Cephalosporin      | 100.0% (124/124)         | 100.0% (24/24)                     | 100.0% (100/100)                  | –       |
| Aminoglycoside     | 94.4% (117/124)          | 100.0% (24/24)                     | 93.0% (93/100)                    | 0.344   |
| Quinolone          | 93.5% (115/123)          | 100.0% (24/24)                     | 91.9% (91/99)                     | 0.353   |
| Oseltamivir        | 42.3% (49/116)           | 52.2% (12/23)                      | 39.8% (37/93)                     | 0.281   |

Table 4

| Protective clothing | All surveyed CCUs N = 128 | All surveyed provincial CCUs N = 25 | All surveyed district CCUs N = 103 | p-Values |
|---------------------|--------------------------|------------------------------------|-----------------------------------|---------|
| Protective clothing | 71.2% (84/118)           | 81.8% (18/22)                      | 68.8% (66/96)                     | 0.222   |
| N95 respirators     | 54.6% (65/119)           | 65.2% (15/23)                      | 52.1% (50/96)                     | 0.256   |
| Medical gloves      | 98.4% (121/123)          | 100.0% (24/24)                     | 98.0% (97/99)                     | 1.000   |
| Sterile gloves      | 96.8% (120/124)          | 100.0% (24/24)                     | 96.0% (96/100)                    | 1.000   |
| Medical goggles     | 56.7% (68/120)           | 69.6% (16/23)                      | 53.6% (52/97)                     | 0.165   |
| Single-use gowns    | 50.0% (59/118)           | 78.3% (18/23)                      | 43.2% (41/95)                     | 0.003   |
| Reusable gowns      | 62.1% (72/116)           | 77.3% (17/22)                      | 58.5% (55/94)                     | 0.103   |
| Head coverings      | 94.3% (114/121)          | 100.0% (23/23)                     | 92.9% (91/98)                     | 0.344   |
| Liquid soap         | 100.0% (124/124)         | 100.0% (24/24)                     | 100.0% (100/100)                  | 0.529   |
| Antiseptic soap     | 84.4% (103/122)          | 79.2% (19/24)                      | 65.7% (84/126)                    | 0.207   |
| Antiseptic hand wash agent | 91.9% (114/124) | 100.0% (24/24) | 90.0% (90/100) | 1.000   |
to 18.9 in Europe and 24.8 in Americas [30]. In 2015, the density of doctors in Vietnam was 8.0 per 10,000 inhabitants [18], an increase from 5.6 per 10,000 inhabitants reported in 2000. Vietnam ranked in the middle among other South East Asia in regards to countries-physician densities [31]. Our study can contribute to the global efforts to better understand the global capacity of ICUs [32] and highlights the need to train, recruit and retain more health care workers to meet the demand of busy (and growing) intensive care units in resource limited settings.

In Vietnam, the national guidance of management for emerging respiratory diseases are established to use as reference for the clinical management at all level of hospitals in the country but are not regularly updated and may lead to mismatch with international guidelines. As management at all level of hospitals in the country but are not regularly updated and may lead to mismatch with international guidelines. As such, they may then need to be evaluated for effectiveness.

Future studies are needed to bridge the gap in the delivery of critical care services in resource-limited settings. With the findings of this study, there is a clear need to 1) define the essential ICU equipment and supplies needed to respond to infectious threats that present with sepsis for all hospital levels; 2) create suitable models of organization for constructing high quality, cost-effective ICUs that can respond to emerging infectious threats, including pre-hospital emergency medical services and critical care transport; 3) develop a transparent approach to modify and adapt international guidelines for local use; and 4) conduct robust evaluations of such interventions on processes of care, outcomes and costs.

This study, indeed, has several limitations. Firstly, the sampling of just 36% of hospitals makes it impossible to exactly gauge the capacity of the Vietnamese medical system, though we believe this purposive and pragmatic snapshot, is reflective of the larger picture in Vietnam, especially those with experience treating patients with SARI and with vigilance for imported case of avian influenza A virus. Secondly, the elements surveyed were also pragmatically chosen and based on national not international guidelines. This does not allow us to assess the hospital’s ability to implement the full recommendations from recently published international guidelines on sepsis and other important safety interventions. Thirdly, the survey about availability of the antibiotics lacks important details and warrants further examination. Fourth, quantifying the structural and human resources are just two aspects of a country’s ability to respond to infectious threats. Other aspects that need to be evaluated include the skills and knowledge of the health care workers in emergency and intensive care, and the system’s current performance on processes of care and patient outcomes. More information is needed on other determinant of quality care.

The limited availability of relevant structural and human resources in selected critical care units in Vietnam makes the implementation of quality care to patients with SARI and sepsis, according to international guidelines, not universally possible.

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