



Dependency and Vulnerability of Intensive Care Medicine in Times of COVID-19 Crisis

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Abstract

Since December 2019, Coronavirus Disease-2019 (COVID-19) spread rapidly all over the world, resulting in pandemic. Through high hospitalization rates and *via* potentially exponential expansion of the disease, the COVID-19 crisis places a tremendous strain on healthcare systems, especially on limited numbers of hospital and Intensive Care Unit (ICU) - beds and equipment. The aim of this study was to elucidate the possible dependency of ICUs in European Countries with Austria as *pars pro toto* on long Trans global supply chains and its potential vulnerability by reported shortages of essential medicines and limited capacities in times of globalization and asserted economic advantages versus the pandemic threat of COVID-19. From 3rd April to 8th April 2020 we performed a short survey with heads of Austria's ICU-wards following a structured questionnaire to enquire their personal experience and assessment. We surveyed nearly half of the head physicians of ICUs (n=40). The 55 percent (n=22) are already treating COVID-19 affected patients. Only 45 percent (n=18) of them had received the amount of personal protective equipment they deemed enough. The 45 percent (n=18) already reported infections within their medical personnel and 35 percent (n=14) already reported supply difficulties in pharmaceuticals. Summarizing the results of our survey we would like to draw attention to the lessons we can learn from the COVID-19 crisis: European countries should establish a national production of key equipment and disposables and should invest in maintaining critical infrastructure especially in those with limited capacities such as health care in general and ICUs in particular.

Keywords: PPE; vulnerability ICU; pharmaceuticals; COVID-19

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Abbreviations

API: Active Pharmaceutical Ingredients; COVID-19: Coronavirus Disease-2019; EFPIA: European Federation of Pharmaceutical Industries and Associations; EU: European Union; GDP: Gross Domestic Product; ICU: Intensive Care Unit; OECD: Organization for Economic Co-operation and Development; PPE: Personal Protective Equipment; SARS-CoV-2: Severe Acute Respiratory Syndrome Coronavirus 2; WHO: World Health Organization

Background

At the end of 2019, a series of epidemic pneumonia cases caused by a novel coronavirus termed as Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) emerged in Wuhan, China [1,2]. Since then, the SARS-CoV-2 spread rapidly all over the world, resulting in a pandemic, which was termed Coronavirus Disease -2019 (COVID-19) by the World Health Organization (WHO).

On January 30th, 2020 COVID-19 had been declared a "public health emergency of international concern" by the WHO and on March 11th, 2020 COVID-19 had been assessed a pandemic for the first time since the H1N1 pandemic in 2009/2010 [1,2]. As of beginning of April 2020 there are far more than a total of 300,000 confirmed cases and more than 20,000 COVID-19 related deaths in Europe [4]. Austria being one of the first countries affected after the European outbreak in Italy. Through high hospitalization rates and *via* potentially exponential expansion of the disease, the COVID-19 crisis places a tremendous strain on healthcare systems, especially on limited numbers of hospital and Intensive Care Unit (ICU) beds and thus necessitates rapid action and countermeasures.

According to the Austrian structural plan of health (Osterreichischer Strukturplan Gesundheit, OESG) and the Organization for Economic Co-operation and Development (OECD) a total of 2.547 ICU-beds are registered in Austria, representing a rate of 28.9 beds per 100,000 populations

Table 1: Results of performed questionnaire (general information).

	All included ICUs	Primary sector	Secondary sector	Tertiary sector
N	40	21 (52.5%)	15 (37.5%)	4 (10.0%)
General information				
Preparedness for COVID-19 patients	33 (82.5%)	17 (51.5%)	12 (80.0%)	4 (100.0%)
Treating COVID-19 patients	22 (55.0%)	12 (57.1%)	7 (46.7%)	3 (75.0%)
Possibility to isolate contagious patients	35 (87.5%)	18 (85.7%)	13 (86.7%)	4 (100.0%)
Availability of emergency plan	40 (100.0)	21 (100.0%)	15 (37.5%)	4 (10.0%)
Availability of adapted guidelines	39 (97.5%)	21 (100.0%)	14 (93.3%)	4 (100.0%)
Availability of adapted international guidelines	40 (100.0%)	21 (100.0%)	15 (100.0%)	4 (100.0%)

COVID-19: Corona-Virus-Disease 2019

Table 2: Results of performed questionnaire concerning equipment.

Equipment	All included ICUs	Primary sector	Secondary sector	Tertiary sector
Expanded capacity	35 (87.5%)	18 (85.7%)	13 (86.7%)	4 (100.0%)
Adequate numbers of ventilators for expanded capacity	33 (82.5%)	16 (76.2%)	13 (86.7%)	4 (100.0%)
Extra stock of PPE	39 (97.5%)	21 (100.0%)	15 (100.0%)	3 (75.0%)
Sufficient amount of PPE	18 (45.0%)	11 (52.4%)	3 (20.0%)	4 (100.0%)
supply difficulties of PPE	36 (90.0%)	19 (90.5%)	13 (86.7%)	4 (100.0%)
informed about supply difficulties in near future	31 (77.5%)	16 (76.2%)	12 (80.0%)	3 (75.0%)

PPE: Personal Protective Equipment

[5]. Although the capacity of ICU-beds is higher than in other countries the COVID-19 crisis led to several concerns in Austria's health care system [6]. Especially the adequate supply of sufficient Personal Protective Equipment (PPE), which is utterly needed in care of infectious COVID-19 patients. This lack of supply turned out as one of the most pressing issues during pandemic all over Europe, since Austria like many other countries of the European Union (EU) relies on supplies from Asia, which were delayed since production fell behind, and global demand skyrocketed as a result of the COVID-19 pandemic.

We therefore tried to elucidate the possible dependency of ICUs in Austria in particular on long trans global supply chains and its potential vulnerability by reported shortages of essential medicines and limited capacities in times of globalization and asserted economic advantages versus the pandemic threat of COVID-19.

Methods

We performed a short telephone survey with heads of ICU-wards in different institutions following a structured questionnaire that has been developed especially for this study to enquire their personal experience and assessment. An additional file shows this questionnaire in detail (Additional File 1). We started our questioning on April 3rd, 2020 on-going until April 8th, 2020. At that time containment measures with exit restrictions, starting on March 16th, 2020, has lasted for a time span of three weeks. Due to the dynamic situation during pandemic with constantly changing export bans and travel restrictions especially in our neighboring countries the questionnaire represents a current snapshot of the situation in that time.

Heads of ICU were called twice, in case of temporary unavailability a return call was asked, or alternatively heads of institutional economic or purchase departments were interrogated.

A descriptive statistical analysis was performed using IBM SPSS 26. Continuous variables are described by median and mean.

Results

Within days we surveyed roughly half (n=40) of the head physicians of ICUs in Austria. Thirty-six percent (n=21) hospitals of the primary sector, 55% (n=15) hospitals of the secondary sector and 29% hospitals (n=4) of the tertiary sector were included in the study. Percentages based on Austria's total number of hospitals of each sector [7]. Detailed results are listed in Table 1.

The 83 percent of ICUs were specifically prepared for COVID-19 patients and 55% are already treating affected patients at their ICU department on week three of the containment measures and social quarantine restrictions. The 50 percent of surveyed ICUs had positions prepared for COVID-19 patients up to 86% mainly by reducing elective surgery. The 88 percent of hospitals can separate contagious patients and have the potential to expand their capacities with additional recovery room or monitored beds. All 40 surveyed institutions have released own guidelines for dealing with (potentially) COVID-19 infected patients mainly adapted from international guideless for the care of COVID-19 cases (Table 1) [8,9].

Only 13% of ICUs included in the survey reported that they could not provide further or enough ventilators for extra entities. The 98 percent of ICUs reported ordering extra PPE for their health care workers. At that time 45% of them had received the amount of PPE they deemed enough. The 90% of surveyed ICUs were already informed about shortage supplies. Detailed results concerning PPE are listed in Table 2 and graphic illustration of results is shown in Figure 1. According to the estimation of heads of ICUs the duration of pandemic should not last more than 6 weeks averagely without facing difficulties in storage and availability of supply (Table 3).

The 78 percent of surveyed ICUs have ordered additional stock of pharmaceuticals like analgesics, opioids, and sedatives and 35% feared or already reported supply difficulties in several pharmaceuticals. The 73 percent were informed or already warned by their economic or purchase departments about further potential or real shortages in near future (Table 4 and Figure 2).

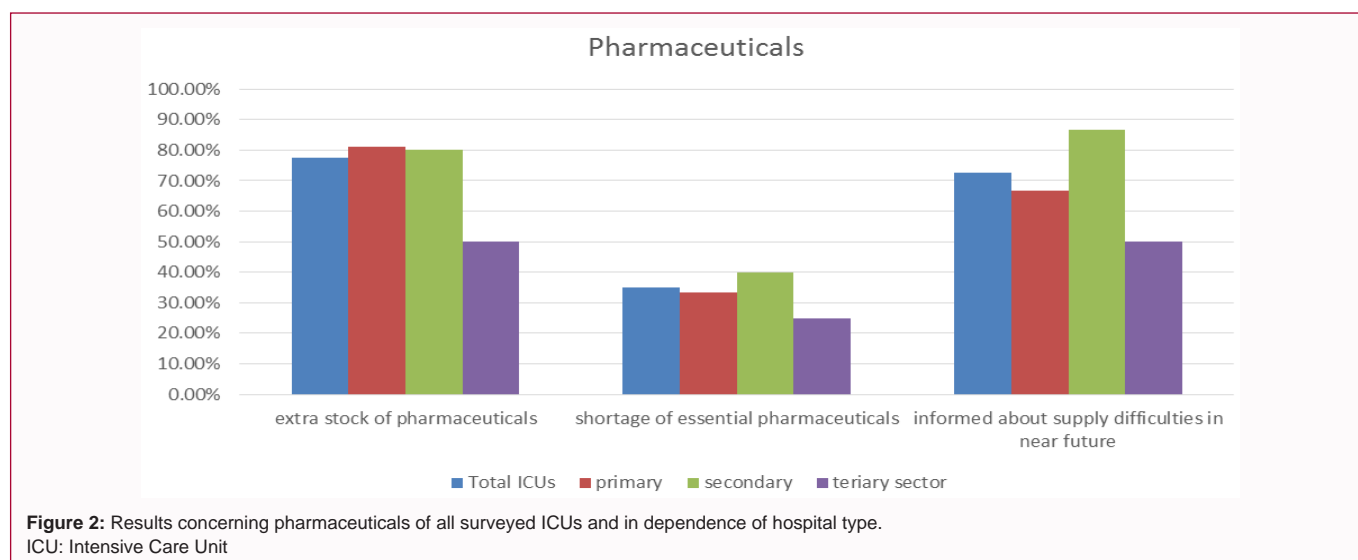
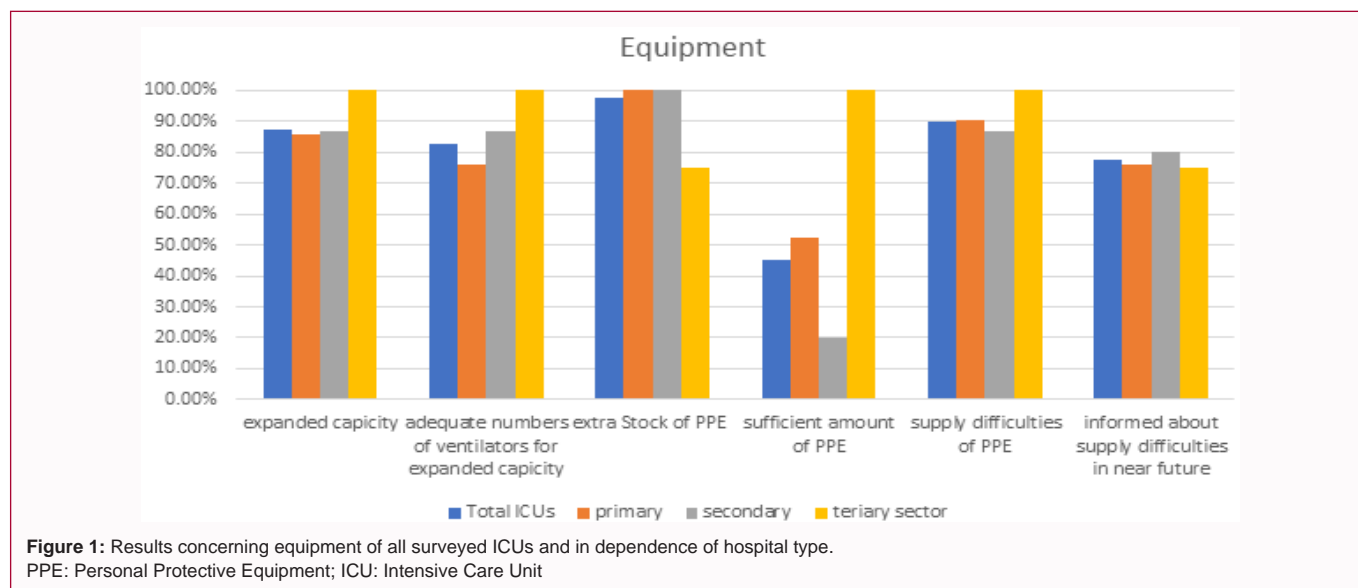


Table 3: Results of performed questionnaire (continuous variables).

	Median	Mean	Minimum	Maximum
Capacity of beds preserved for COVID-19 patients (percent)	74.12%	86.00%	10.00%	100.00%
Rate of commuting medical personnel (percent)	11.51%	9.00%	0.00%	35.00%
Maximum duration of pandemic without severe concerns (weeks)	5.8 weeks	4.0 weeks	0.5 weeks	12.0 weeks

COVID-19: Corona-Virus-Disease 2019

Fifty-five percent of surveyed institutions employ commuting nurses and 68% of doctors from neighboring countries such as Hungary, Slovakia, and the Czech Republic (Table 5, Figure 3). As a result, 28% of ICUs reported difficulties in filling the duty roster due to suddenly implemented travel restrictions, others could compensate because almost 68% were reporting problems in border crossing of personnel (Table 3). The 45% of institutions already reported cases of COVID-19 illness and quarantine measures within their medical personnel two weeks after start of containment measures.

Discussion

Our data show the dependency of ICUs in Austria in particular on long Trans global supply chains of PPEs and essential pharmaceuticals

and thus its non-insignificant vulnerability by reported shortages in times of COVID-19. As seen in our results, the 90 percent of ICUs registered supply disruptions of PPE and 35% registered shortages of far more than 3 different pharmaceuticals. The 78 percent of questioned ICUs feared or were already informed about further supply difficulties concerning PPE in near future. These results were also reflected in assessments of the heads of surveyed ICUs. A maximum duration of pandemic of 6 weeks without serious impact on health care system was estimated by most chief physicians mainly depending on availability of PPE and pharmaceuticals. Not only dependency on these factors was notably but also on commuting medical personnel from neighboring countries that made up on average 12% of medical personnel generally. Therefore, these three factors can be identified as

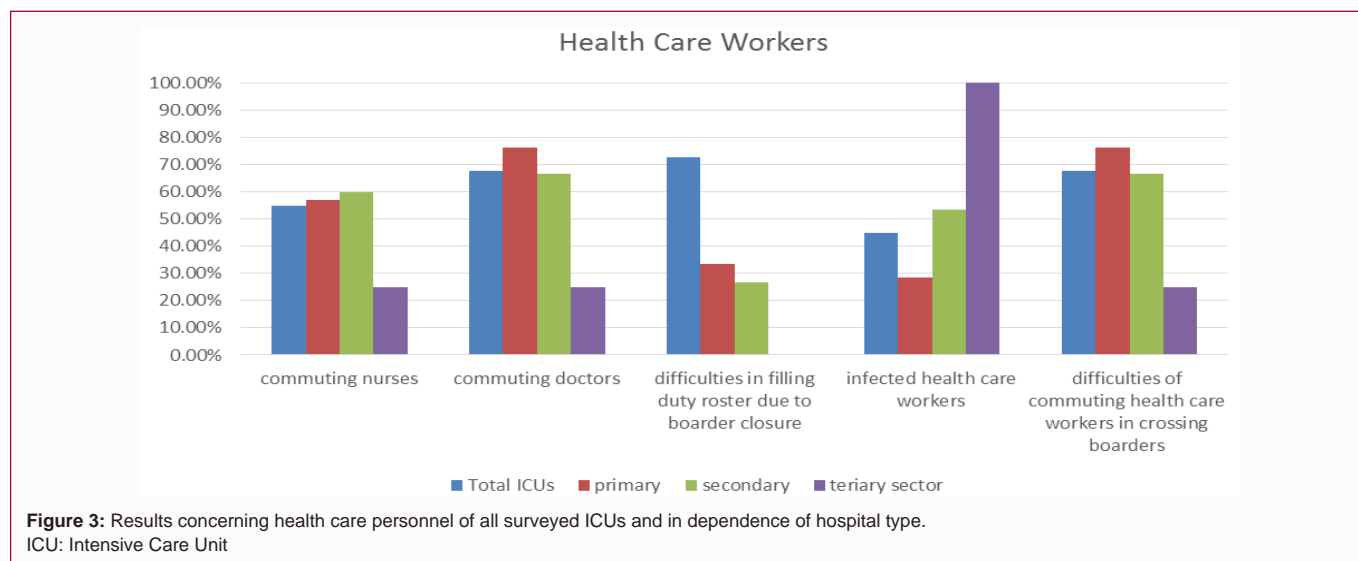


Figure 3: Results concerning health care personnel of all surveyed ICUs and in dependence of hospital type. ICU: Intensive Care Unit

Table 4: Results of performed questionnaire concerning pharmaceuticals.

Pharmaceuticals	All included ICUs	Primary sector	Secondary sector	Tertiary sector
Extra stock of pharmaceuticals	31 (77.5%)	17 (81.0%)	12 (80.0%)	2 (50.0%)
Shortage of essential pharmaceuticals	14 (35.0%)	7 (33.3%)	6 (40.0%)	1 (25.0%)
Informed about supply difficulties in near future	29 (72.5%)	14 (66.7%)	13 (86.7%)	2 (50.0%)

Table 5: Results of performed questionnaire concerning health care workers.

Health care workers	All included ICUs	Primary sector	Secondary sector	Tertiary sector
Employ commuting nurses	22 (55.0%)	12 (57.1%)	9 (60.0%)	1 (25.0%)
Employ commuting doctors	27 (67.5%)	16 (76.2%)	10 (66.7%)	1 (25.0%)
Occurrence of difficulties in filling duty roster due to boarder closure	29 (72.5%)	7 (33.3%)	4 (26.7%)	0 (0.0%)
Infected health care workers	18 (45.0%)	6 (28.6%)	8 (53.5%)	4 (100.0%)
Difficulties of commuting health care workers in crossing boarders	27 (67.5%)	16 (76.2%)	10 (66.7%)	1 (25.0%)

the most pressing issues in times of pandemic.

Although Austria seems to be in a comparably favourable condition in times of COVID-19 crisis, this is mainly the result of preparation of high capacities (on average nearly 75%) that ICUs can provide especially for COVID-19 patients and lucky coincidences. As the first affected country inside the EU, Italy is one of the most affected countries in the EU. At that time, this virus was new, and not much was known about it, leading to plausible misjudgments and therefore Italy’s health care system got overwhelmed by suddenly high volumes of COVID-19 patients and limited hospital capacity during flu-season. Like in many other countries, hospitals tend to run close to full capacity, with up to 87% average occupancy [10].

From Italy’s experience Austria could draw attention to lessons learned from COVID-19 pandemic and has relatively early taken strict measures to avoid transmission, such as social distancing, school closures and event cancellations. With the aid of these restrictions time was gained to prepare hospitals as good as possible, expand testing capacity and thus keep death rates low. Additionally, the fact that people coming from regions of high population density such as Vienna or Lower Austria had holiday season a few weeks before outbreak of COVID-19 in Tyrol and thus could not visit these areas with high proportion of infected people resulting in moderately high infection rates in urban areas. Also, due to relatively early announced travel warnings majority of the Austrian population did not attend,

for example, the carnival in Venice, which could have resulted in massive viral transmission.

Nonetheless in contrast to the positive findings of our survey we could elaborate on three major issues of Austria’s ICU in fighting COVID-19:

First, in our survey more than a half of responding heads of ICUs in Austria stated not getting enough high-class disposable PPE allocated for their employees and nearly all of them reported supply difficulties. About a maximal duration of pandemic of up to 6 weeks without serious negative impacts on our health system was speculated by responding heads of ICU (chief physicians), mainly arguing by stable supply chains of PPE.

In this context, we may underline that for adequate protection of medical personnel especially during the performance of aerosol generating procedures such as intubation bronchoscopy and suctioning a PPE is indispensable [9]. Shortages result in inability of health care workers to protect themselves or their patients from being infected and thus will infect others [11]. In most affected countries such as Italy as on March 30th, 2020 9% of medical personnel got infected [10,12], many of whom thereafter died. Since the outbreak of COVID-19 pandemic the demand on PPE increased exponentially, soon leading to depleted supplies. According to the WHO the industry must increase manufacturing by 40 percent to meet rising global demand [11], due to economic globalization of health care

and decentralized production of disposables such as PPE to save costs, like many other countries in the EU, Austria buys masks, goggles, impervious gown and gloves mainly from Asia, resulting in high dependency of secure global supply chains. Closing of borders worldwide and ban of exports of Asia therefore aggravated the shortage of PPE. But also, within Europe, the crisis has piled stress onto intra-European supply chains with new border checks causing traffic jammed trucks. Recently also reported, transporters delivering PPE got confiscated on transportation route in transit countries. As a result, the Austrian government had to transport the equipment by air leading to enormous increase of purchasing costs. However, not only the availability but also the safety and efficacy of PPE are essential for health care workers. Recently published, a disproportional amount of masks, imported from China, failed in reliable safety testing. As a reaction to these developments Austria already started producing masks in local textile companies, especially in Vorarlberg.

Second, 35% of surveyed heads of ICUs reported shortages in more than 3 different pharmaceuticals for COVID-19 and non-COVID-19 patients.

Supply disruption of medications such as opioids, analgesics, antibiotics, and sedatives has been a global problem repeatedly during in the past decades and is increasingly affecting the EU causing widespread human misery [13]. The Austrian generics producer's association (OeGV/Österreichischer Generikaverbund) reported shortages in 230 pharmaceuticals already in November 2019 [14]. As recently published by our group, supply shortages may significantly affect quality of care with e.g. lack of remifentanyl causing significantly longer mechanical ventilation times and consecutively significantly prolonged ICU stay, even under normal circumstances [15].

While Europe is one of the world's top manufacturers of drugs, the raw ingredients termed as Active Pharmaceutical Ingredients (APIs) often are imported from China or India. According to the European Federation of Pharmaceutical Industries and Associations (EFPIA) as a result of rapid growth of the market and research environment in emerging economies such as China, India and Brazil during the last years, the production of APIs started to migrate from Europe to these fast-growing markets [16-18]. This allows countries of the western world producing cheaper generic versions of pharmaceuticals and these normally outweigh costs of transportation and custom clearance by far.

APIs are responsible for the pharmaceutical effect of formulated pharmaceuticals and are mainly produced in China (60.5%), whereas only 27.9% of global needs of APIs are produced in western Europe [17,18]. The situation aggravated under COVID-19 due to temporary lockdowns of manufacturing sites, worker quarantines, travel restrictions impacting exports, export bans, increased demand for medicines used to treat COVID-19 patient and stockpiling by hospitals, by individual citizens or at Member State level in the EU [16]. Additionally, the most affected countries in the COVID-19 crisis in the EU, Italy, and Spain, are the main producers of APIs in Western Europe [18]. The European Commission published guidelines to fight shortages in reaction to depleted supply in many hospitals, mainly located in Austria, Italy, Sweden, Finland, and France [18,19].

Third, in more than the half of surveyed ICU wards nurses and 68% of doctors are employed commuting from neighboring countries - especially in boarder regions, representing a mean rate of 11.5% generally. Difficulties in crossing boarders due to travel restrictions

occurred in two-thirds of Austria's critical care wards and as a result urgently needed specialized intensive care personnel is lacking.

As health care personnel is in the role of first responders in COVID-19 pandemic, countries try to compensate staff shortage by increasing the number of medical personnel by mobilizing inactive and retired health care professionals, even if they are at higher risk of severe infection [1,20]. Countries that spent a lot of Gross Domestic Product (GDP) on health expenditures, such as Switzerland, Norway and Germany have both relatively high numbers of doctors and nurses and are therefore in a more favourable situation in times of the COVID-19 pandemic. Austria has a relatively high number of doctors (approximately 5, 3 per 1000 population) but low numbers of nurses (approximately 7 per 1000 population). In contrast the corresponding numbers for Germany are 4, 3 doctors and 13 nurses per 1000 population respectively [20]. A published study from the Austrian Ministry for Social Affairs in December 2019 reported an additional 13,000 nurses will be required in Austrian hospitals in 2030 [21]. Especially staff working on ICU is extensively trained and specialized in caring for critically ill patients and operating with highly sophisticated equipment such as monitoring devices, ventilators, and extracorporeal organ support devices. Therefore, quick recruitment or training of staff from other departments or professional groups is not a viable option.

Conclusion

Summarizing the results of our survey we would like to draw attention to the lessons we can learn from the COVID-19 crisis in the EU: European Countries with Austria as a pars pro toto should establish a national production of key equipment and disposables, at least a minor part of PPE as well as key pharmaceuticals. Secondly various stake holders of health care should undertake efforts to raise attractiveness in particular of health care professions to prevent dependency. This would not only reduce the current dependency on commuting health care personnel but eventually also compensate for the additional demand in the future. Therefore, European countries need to improve far distance supplies and invest in maintaining critical infrastructure especially in those with limited capacities such as health care in general and ICUs in particular. Although cost savings in health care systems due to reduction of beds, hospitals, and medical personnel, outsourcing pharmaceutical and PPE production seem appropriate during usual times, these apparent benefits could easily turn into substantial disadvantages in times of crisis.

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