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MINI REVIEW

Tele-ICU: the way forward in geriatric care?

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Abstract Aging population is set to increase in the near future, and will need specialized care when admitted to ICUs. The elderly are beset with chronic conditions, such as cardiovascular, COPD, diabetes, renal complications and depression. Specialist opinions can now be made available through telemedicine facilities. Tele-ICU is a specialized hub consisting of highly skilled staff trained in critical care able to deliver timely, quality care service to patients admitted to ICUs in remote areas using highly advanced information technology services. These specialists in the tele-ICU hub are able to analyze and gather data arriving at timely interventional management decisions and provide this vital feedback to the nursing staff and doctors manning remote ICU locations where specialized intensivist may not be available. Known clinical benefits of such a system include better patient outcomes, reduced medical errors, mortality and reduced hospital length of stay. The main disadvantage in implementation could be the upfront high cost involved, for which low-cost models are being explored. In the face of delivering such remote care, it is up to the local health policy to make legislative changes to include associated legal and ethical issues. Considering the burgeoning aging population, tele-ICU could become the way forward in delivering geriatric critical care.

Keywords Telemedicine · Tele-ICU · Geriatric care

Introduction

Aging is now a worldwide phenomenon. In many parts of the world, it is not uncommon to come across persons aged more than 80 years old. Though the numbers may seem small today, the United Nations has estimated that, 80- and-over age group is growing faster than any other, and is expected to continue as the fastest growing segment of the population for at least the next 50 years [1]. Although there is an apparent difference in the aging population among the more developed and less developed nations, it can be observed that individuals over the age of 60 will form an increasing percent of the global population by the year 2050

There are profound implications as a consequence of population aging, especially in the healthcare sector. With advancing age, the overall health begins to decline resulting in the demand for long-term continuous care. Medical expertise and care is hard to come by, even in the remote areas of industrialized nations. Hence, a solution driven by modern technology came into being.

This review article discusses the current role of telemedicine for intensive care, and the implications for geriatric intensive care through a tele-intensive care unit (tele-ICU). The purpose of this review is put into perspective, in a single place, the different aspects of tele-ICU care, including issues in geriatric care, based on current data from recently published systematic reviews and articles.

The telemedicine concept and implementation

It was suggested that with the advent of recent technological advances, it was possible that a physician seated in

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his office could offer services to patients in remote areas through telecommunication and information technology essentially cutting travel costs of the physician and the patient [2]. This strategy was successfully applied to many medical disciplines, for instance, in dermatology, pathology, and radiology. Data were transmitted via the internet so that medical experts could interpret the data sent. Video imaging further enhanced medical care by providing "real-time" diagnosis and advice.

Currently, the American Telemedicine Association (ATA) provides practice guidelines for various services in telemedicine. These standards form the basic foundation for uniform, quality patient care and safety, grounded in empirical research and clinical experience in the various fields of medicine [3]. These include recommendations for mental health, ocular health, dermatology, and pathology.

The goal of telemedicine is to provide timeliness and expert quality care. Initially, interpretation of data from radiographic images and cardiology-related investigations including ECG and echocardiography was most popular through telemedicine, practices that are followed even today with great success [4, 5]. Geriatric experts were able to assess patients with neurosurgical issues and urology using teleradiology [6]. This resulted in fewer hospital admissions and emergency departmental visits. Videoconferencing helped paramedical and geriatric staff to provide psychiatric advice and judge cognitive patients among nursing home residents. Other than declining cognitive function, geriatric patients also need continuing care for chronic diseases and their outcomes. These include hypertension, diabetes, respiratory conditions, heart failure, COPD, arthritis and depression. This formed the basis of the Whole System Demonstrator Programme in the UK wherein electronic sensors or equipment that monitored vital health signs remotely, from home or while on the move. These readings were automatically transmitted to an appropriately trained person who could monitor the health vital signs and make decisions about potential interventions in real time, without the patient needing to attend a clinic. Telecare involved personal and environmental sensors in the home that enable people to remain safe and independent in their own home for longer. 24 h monitoring ensures that should an event occur the information is acted upon immediately and the most appropriate response from remote physicians is available on an immediate basis [7].

Home telemonitoring, an application of telemedicine in which physiological and biological data are transferred directly from the patients' home by the patient or carer to a telemonitoring center to monitor patients, interprets the data, and makes clinical decisions [8]. Initial studies had established definite benefits when patients could readily access consults with the medical personnel in the remote unit. Most patients felt included in the process of care, making them feel secure, especially when positive outcomes were noted in their medical conditions. An updated systematic review on the outcomes of home telemonitoring in aging populations was published recently [9]. A total of 62 articles were included in the review. The results indicated that patients with diabetes showed a trend for better glycemic control, asthma sufferers showed a significant improvement in PEF, a significant reduction in the symptoms associated with this illness, and a large improvement in perceived quality of life, and hypertensives demonstrated a better control of blood pressure. Among patients with heart failure, telemonitoring resulted in reduced hospital readmission rates, emergency room visits, and length of hospital stay. The results conclude that telemonitoring from home can be applied successfully to benefit a significant proportion of aging population with stable medical conditions.

However, most elderly have complex medical conditions requiring intensive care admissions. The need for providing various models of tele-ICU has became imperative in view of the aging populations increasing need for ICU care and the shortage of intensivists available at all medical centres.

Telemedicine in intensive care units: tele-ICUs

Telemedicine in critical care areas is a specialty subset of the overall field of telemedicine. Tele-intensive care unit (tele-ICU) telemedicine typically involves specialists located at a dedicated central hub providing care to patients in multiple, remotely located ICUs. These specialists were directly involved in diagnosis and management decision making based on the positive reviews and benefits regarding the role of telemedicine in other specialities, providing intensive care through telemedicine was expanded. Tele-ICU was founded as a means of delivering clinical expertise of intensivists located remotely to hospitals with inadequate access to intensive care specialists [10, 11].

A tele-ICU involves a multidisciplinary team of specialists located at a dedicated central hub providing care to patients in multiple, remotely located ICUs Intensivists and highly skilled nurses and paramedical staff use audio and video links to assist bedside caregivers in monitoring and managing critically ill patients. This team in the tele-ICU hub is able to even provide assistance to multiple ICU locations. The data transmitted from the patient's bedside can even provide trends and predict potential future problems that can arise and set off an alarm to alert downward trends requiring intervention and managed by the highly trained intensivists and nursing staff placed in tele-ICUs providing timely intervention to a specialist at the remote location.

Generally, in an intensive care unit (ICU), the closed ICU model, the care of every critically ill patient is the responsibility of an intensivist-led team or a mandatory consultation by an intensivist, specializing in the multidisciplinary nature of ICU care, should the need for intervention arise [12]. Therapy is based on guidelines and recommendation made by international bodies such that a significant reduction in mortality and length of stay (LOS) is observed. However, with the current trend of increasing numbers in the aging population, intensive care would be needed by more individuals than what is available in the closed ICU model. Conversely, an open model would be more feasible where any physician may be able to manage the care for patients without having the need for an intensivist visit. This type of technology-driven remote care can be used to provide continuous 24/7 ICU patient management to achieve improved clinical and economic outcomes. The success associated with such remote care programs can benefit patients with quality care and reducing costs when on-site intensivist coverage is not available, especially in community and rural hospital ICUs. Further, certain elderly patients have long-term complex medical problems. Such patients are usually transferred as in patients at long-term acute care hospital facilities [13]. These patients usually need intensive therapies, are slow to recover, and due to the nature of their delicate condition require higher degree of care offered in a general medical unit. This level of care would need an intensivist and skilled nursing staff via telemedicine facility to produce successful outcomes in these patients, so that they do not develop complication requiring them to be shifted to a short-term ICU.

The Leapfrog group has provided guidelines for ICUs, which recommend intensivist-led care for all patients in ICUs, to reduce in-hospital mortality. Hence, tele-ICU is implemented for patient safety reasons. A study initiated by the group found that up to 98,000 Americans die every year from preventable medical errors made in hospitals alone. The Leapfrog model suggests that over 40 % (over 57,000) deaths that occur in the ICU could be avoided with intensivist-led care [14]. There is substantial evidence that patient outcomes are better in ICUs that are managed by physicians and nursing staff with a specialty in critical care medicine [15–17].

Tele-ICU involves a highly technology-driven complex mix of hardware combined with software applications. The technology includes applications such as smart alarms, collection and analysis of trends in the condition of the patient, and clinical care evidence-based algorithms. This has helped in reducing potential medical errors. However, alongside these vital clinical benefits to the patients, patient and staff acceptance of the system, and cost implications for such a complex set-up could pose as stumbling blocks in adopting the tele-ICU model.

Clinical benefits of tele-ICU

The implementation of tele-ICU interventions has been associated with definite clinical benefits, including reduction in ICU mortality and hospital and ICU length of stay (LOS), as well as best practice adherence and lower rates of preventable complications (Table 1) [18]. This was concluded in a benchmark large study ($n = 6{,}290$) with adults admitted to 7 ICUs (3 medical, 3 surgical, and 1 mixed cardiovascular) on 2 campuses of an 834-bed academic medical center. Best practice adherence to venous thrombosis, cardiovascular complications, ventilator-associated pneumonia, and stress ulcers, and other preventable complications were lower with tele-ICU intervention. Preintervention cases were obtained by identifying consecutive hospital discharge cases from an administrative database for cases managed in each of the 7 ICUs. All adults admitted to an ICU bed were included. The tele-ICU intervention implementation dates for the ICUs were staggered. The study was powered to have an 80 % probability for detecting a 3.5 % improvement in mortality using a 1:3 allocation of patients in the preintervention group and in the tele-ICU group at a significance level of 0.05. The tele-ICU team participated in key critical care delivery processes throughout the entire day (24 h every day). The off-site team included an intensivist and used tele-ICU workstations. The tele-ICU team serially reviewed the care of individual patients, performed real-time audits of best practice adherence, performed workstation-assisted care plan reviews for patients admitted at night, monitored system-generated electronic alerts, audited bedside clinician responses to in-room alarms, and intervened 18 when the responses of bedside clinicians were delayed and patients were deemed physiologically

Table 1 Reduction in all study parameters was observed indicating benefit of tele-ICU for critically ill adult populations

Study parameters	Preintervention period	Tele-ICU intervention period
Hospital mortality	13.6 %	11.8 %
Best clinical practice adherence	DVT: 85 %	DVT: 99 %
	Stress ulcers: 83 %	Stress ulcers: 96 %
	Cardiovascular protection: 80 %	Cardiovascular protection: 99 %
	VAP: 33 %	VAP: 52 %
Hospital length of stay	13.3 days	9.8 days

DVT deep vein thrombosis, *VAP* ventilator-associated pneumonia (adapted from [18])

unstable. The key findings of the study are illustrated in Table 1.

Another recent publication examined another interesting aspect of tele-ICU [19]. The ICU model of care in the preintervention period was an "Open" ICU where the primary care provider (PCP) admitted patients to the ICU and continues to act as the primary physician, with consult on some patients with an inhouse intensivist who will manage these patients during daytime only. The ICU in the intervention period remained "Open." The only new ICU intervention was by tele-ICU. The tele-ICU program operated on a 24/7 schedule and was staffed by two board-certified intensivists, five critical care nurses with at least 5 years of bedside critical care experience (5–35 years, with an average of 18.6 years), and two unit secretaries.

The clinical outcome of patients was observed for differences during daytime (7 am to 7 pm) and nighttime (7 pm to 7 am) shifts. Among 1,026 patients admitted during daytime shift ($n = 199$ in the preintervention group; $n = 827$ in the tele-ICU group), the ICU mortality was lower in the tele-ICU group [9.0 % during the preintervention period vs 4.9 % during the tele-ICU intervention period (OR = 0.52, 95 % CI 0.29–0.93, $P = 0.02$)]. Among 1,797 patients admitted during nighttime shift ($n = 431$ in the preintervention group; $n = 1{,}366$ in the tele-ICU group), the ICU mortality was significantly lower in the tele-ICU group [7.6 % during the preintervention period vs 3.4 % during the tele-ICU intervention period (OR = 0.42, 95 % CI 0.26–0.66, $P = 0.0001$)] (Table 2). These results suggested that ICU mortality significantly decreased with tele-ICU intervention in both daytime and nighttime shifts, indicating a decreasing trend in hospital mortality in the daytime shift group and a statistically significant decrease in hospital mortality in the nighttime shift group.

Data from two recent systematic reviews and meta-analysis have indicated that telemedicine was associated with lower ICU mortality among critically ill patients. In an analysis of 11 studies wherein the mean ages of patients were 62 years (range 5.5–66 years) and 64 years (range 5.3–65 years) in the standard-care and intervention groups, respectively, the primary outcome was ICU mortality [20]. Secondary outcomes included hospital mortality and ICU and hospital LOS. Pooled data revealed that tele-ICU interventions reduced ICU and hospital mortality and LOS in critically ill patients. This has been attributed to improve clinical outcomes by improving adherence to best practices in the ICU. These results almost mirror the findings of a previous systematic review and meta-analysis [21]. In that analysis, pooled data were derived from 13 studies involving 35 ICUs. The findings indicated that tele-ICU coverage was associated with a reduction in ICU mortality and LOS but not with lower in-hospital mortality or hospital LOS.

Patient care processes have also been found to be superior in tele-ICUs. Most patient's clinical benefits and outcomes are as a result of evidence-based medicine compliance. Specific alerts and other applications in tele-ICU enabled centers have helped in less medication errors [22].

Table 2 ICU mortality outcomes during the shift timings in patients admitted to ICU (data adapted from [19])

Shift timings	Preintervention (% ICU mortality)	Tele-ICU (% ICU mortality)	*P* value
7 am to 7 pm (daytime) ($n = 1{,}026$)	9 % ($n = 199$)	4.9 % ($n = 827$)	0.02
7 pm to 7 am (nighttime) ($n = 1{,}797$)	7.6 % ($n = 431$)	3.4 % ($n = 1{,}366$)	0.0001

Acceptance of tele-ICU by staff

Staff acceptance of tele-ICU monitoring is critical in providing quality intensive care to the patients admitted into the ICU. Other than the critical care intensivist, the tele-ICU nurses play a vital role. They are highly skilled and efficient and an important cog in the wheel in contributing maximally to patient outcomes [23].

Since this is a rather modern method of delivering ICU care, many studies have explored how the staff dealt with the technology. A systematic review of 23 studies that focused on various aspects of tele-ICU found that despite initial resistance from the staff, the overall acceptance was favorable [24]. Nearly all studies indicated that patient care quality was superior if tele-ICU was implemented. However, some staff found the workload to be increased, while others found it to be decreased. At times there appeared to be some confusion with different advices coming from the remote intensivist and the attending ICU physician. Some mechanical failures of the system were also reported. The analysis concluded that some of these findings needed to be studied further if tele-ICU was to be propagated in more centers.

Even in a highly staffed ICU, the provision for nighttime telemedical services improved staff satisfaction when compared to controls in a similar environment without the benefit of tele-ICU services [25]. The nursing staff were found to be quick to accept the challenges of learning new concepts in critical care delivery and were satisfied with their job as tele-ICU information managers in a study conducted with 50 nurses in 5 tele-ICUs [26]. In fact, a unique, entirely nurse driven, non-traditional tele-ICU model successfully provides critical care nursing expertise

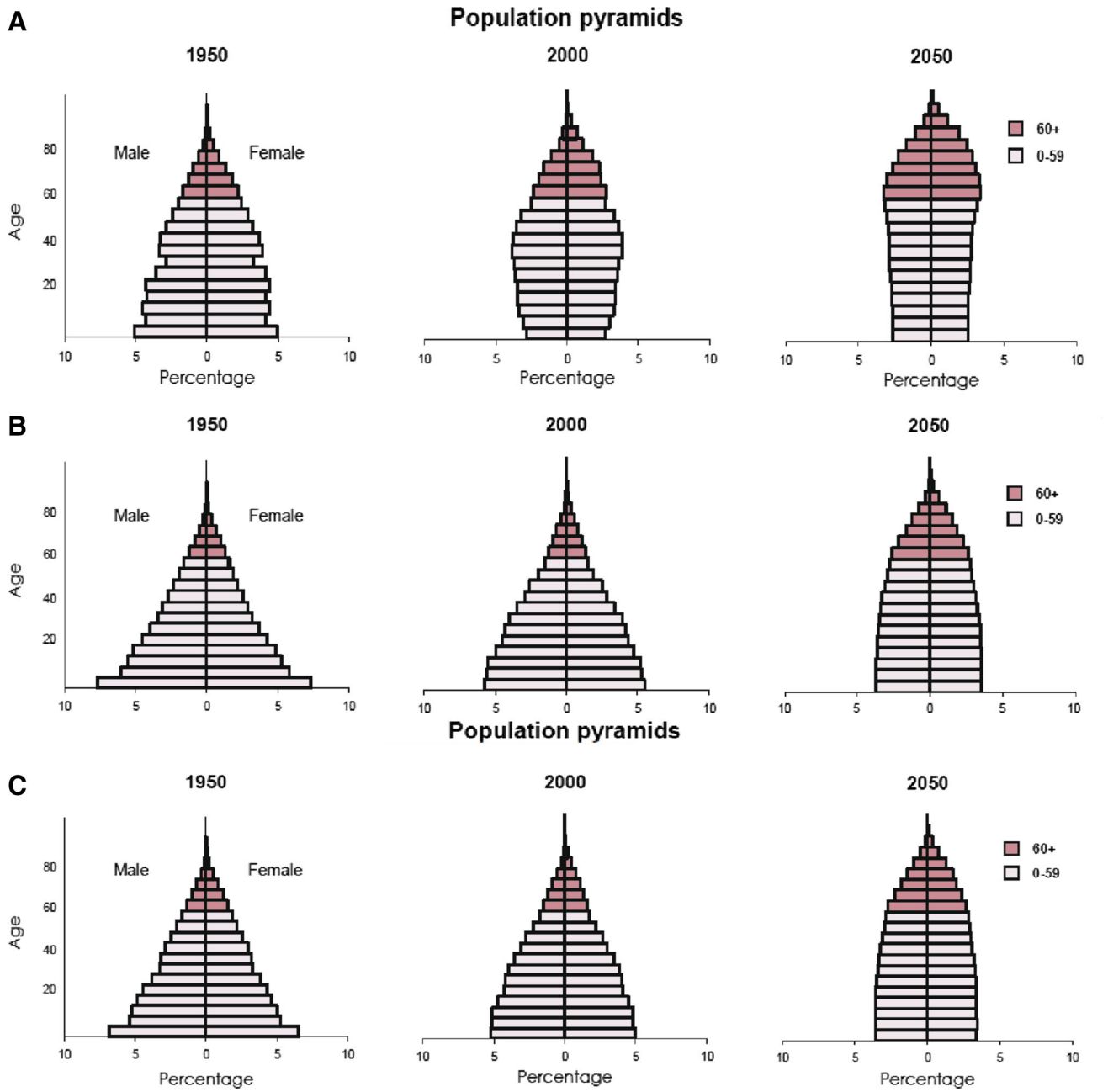

Fig. 1 Population pyramids constructed from data with the United Nations from 1950 up to population estimates for the year 2050. **A** data from more developed nations. **B** Data from less developed nations. **C** Data compiled for the world's population [1]

to critically ill rural veterans. Immediate rapid care is carried out with advice from specialists and potential transfers to specialist centers are carried out by the tele-ICU nurse [27, 28].

Cost effectiveness of tele-ICU

If tele-ICU is the way forward to the burgeoning aging population, cost implications for setting up the facility can be an important factor. Most of the tele-ICU studies have been conducted in the United States of America [29]. New technology is almost always associated with increased costs. From a systematic review analysis of 25 clinical studies that also evaluated costs in addition to clinical outcomes, it was realized that a substantial upfront capital for tele-ICU set-up would be required. The adoption of such "centralized" tele-ICU services would need support from technical staffing in addition to training of healthcare professionals to the system. An estimated cost of 2–5 million USD with a running cost of USD 600,000 to 1.5

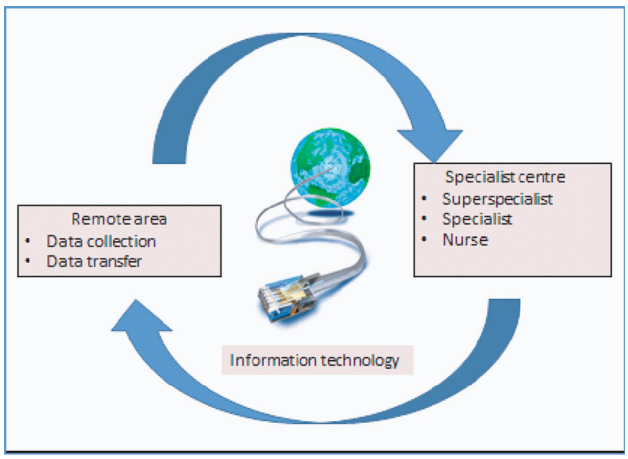

Fig. 2 Basic concept of telemedicine: transmitting and receiving data in a healthcare environment

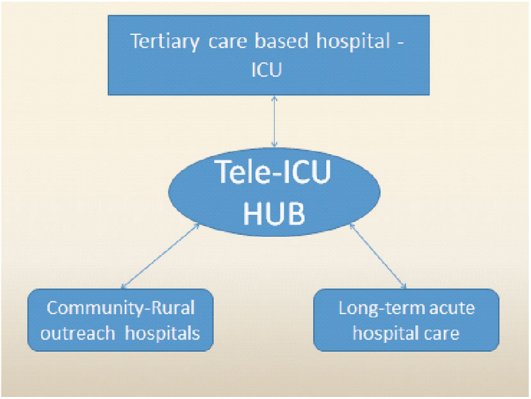

Fig. 3 A central tele-ICU hub connecting multiple locations

million USD per year has been derived. The flipside of the issue is that a net present value of $2.5 million USD could be saved by creating the ability to care for one new ICU patient/day if a 10 % reduction in ICU length of stay was guaranteed. These are only estimates, and more studies on actuals are required based on the size and settings of the facility. Cost-effectiveness of support tele-ICU monitoring will probably be ideal if provided to the sickest patients, in limited number of beds as it has the potential to reduce mortality without significantly increasing cost in this specific group of patients [30].

To lower costs, a "decentralized" model has been developed. The InTouch Health (Santa Barbara, California) system involves a robot that can be controlled by a medical staff. The robot is able to scan via an in-built video camera, the readings on the various monitors around the patient and relay important information via wireless technology. This robot also has an in-built stethoscope and blood pressure tools to monitor the patient's vital information. The software needed to access the robot' information can easily be installed on a personal laptop of an intensivist or ICU staff providing quality medical advice and care. This has seemed adequate in at least 450 hospitals across the United States, until 2011, who have successfully adopted this model [31]. Other hybrid models are in the process of development Figs. 1, 2, 3.

Tele-ICUs: geriatric specific care

Clinical studies from Hong Kong and Singapore offered geriatric assessment team to a local nursing home to provide management advice instead of a clinic or outreach visit, and resulted in 9 % fewer ED attendances and 11 % fewer utilized hospital days. User satisfaction has been reported from Australia as well. Office practice or ambulatory care would require the patient to be introduced to the remote specialist by a local health facility or worker. There are many reports of successful clinics providing specialist advice by telemedicine. Detailed analyses of patient outcomes, satisfaction levels and costs have been reported. Costs of the service were critically dependent on the type of consultant, telecommunication charges and the locally based health worker's time, initial consultation which included the patient and their local doctor, but patient satisfaction was higher in the telemedicine group. Geriatric practice through videoconference was reported as acceptable for patients with mild dementia, but its utility declined as the patient is less able to comprehend the interview, or has significant sensory impairment. Since cognitive function is an important component of comprehensive geriatric assessment, these reports provide valuable guidance, but the more impaired patients are less likely to tolerate unfamiliar technology, unless supported by skilled staff at the time, as in the nursing home experience [32, 33].

As mentioned earlier, chronic disease management has also been reported in a number of studies, which have relevance to geriatrics. The control of heart failure, diabetes and chronic respiratory disease has been improved by an integrated approach, with non-invasive passive monitoring of various physiological data, support of a nurse case manager and an electronic medical record, resulting in less hospital bed and emergency department use and greater patient satisfaction. Ongoing care in the community has been augmented by telephone, with improvements in heart failure and patient satisfaction, and depression. The addition of a video link to usual home care has been shown to be well accepted and cost-effective. In areas where geriatrician expertise is currently unavailable, telemedicine has the capacity to allow remote consultation, which can be supported by a trained health worker locally, using a protocol for comprehensive geriatric assessment. It may be more feasible than relying on recruitment of a local

geriatrician but overall geriatrician numbers will continue to limit the availability of expertise [32, 34].

Ethical and legal issues in providing tele-ICU geriatric care

When nurses are the point of contact for providing care, specialized nurses are chosen who fulfill the Nurse Licensure Compact, a body in the United States that allows specialized nurses multiple states to practice, that helps resolve some of these jurisdiction issues. Legal issues such as accountability and malpractice, etc. are also still largely unsolved and difficult to address. The American Association for Critical Care Nursing (AACN) Certification Corporation considers the American Nurses Association (ANA) Code of Ethics for Nurses foundational for nursing practice, providing a framework for making ethical decisions and fulfilling responsibilities to the public, colleagues and the profession. AACN Certification Corporation's mission of public protection supports a standard of excellence that certified nurses have a responsibility to read, understand and act in a manner congruent with the ANA [35].

Physicians employed in remote locations as well local teams at the tele-ICU units in specialized centres in the USA have to mandatorily possess restrictive licensure laws that require a practitioner to obtain a full license to deliver telemedicine care across state lines. Typically, states with restrictive licensure laws also have several exceptions (varying from state to state) that may release an out-of-state practitioner from the additional burden of obtaining such a license. A number of States require practitioners who seek compensation to frequently deliver interstate care to acquire a full license. If a practitioner serves several states, obtaining this license in each state could be an expensive and time-consuming proposition. Even if the practitioner never practices medicine face-to-face with a patient in another state, he/she still must meet a variety of other individual state requirements, including paying substantial licensure fees, passing additional oral and written examinations, and travelling for interviews. Regulations concerning the practice of telemedicine vary from state to state. Physicians who will be prescribing over the Internet to patients should mandate strict controls on their practice to insure that they stay compliant with the various State Medical Board Regulations concerning Internet Prescribing [36].

Six main concerns regarding ethics have been raised when robotics are used in providing care in tele-ICU situations, namely: (1) the potential reduction in the amount of human contact; (2) an increase in the feelings of objectification and loss of control; (3) a loss of privacy; (4) a loss of personal liberty; (5) deception and infantilization; (6) the circumstances in which elderly people should be allowed to control robots [37].

Summary

Telemedicine has the capacity to allow remote consultation, which can be supported by a trained health worker locally, using a protocol for comprehensive geriatric assessment for chronic disease management. To provide intensive medical care, tele-ICU interventions are provided by a remote intensivist that has demonstrated positive clinical outcomes in terms of hospital mortality, reduction in length of hospital stay, and prevention of complications. Despite the limited studies demonstrating such evidence, many experts and the Critical Care Societies Collaborative, which includes the American Association of Critical Care Nurses, the American College of Chest Physicians, the American Thoracic Society, and the Society of Critical Care Medicine, arrived at a conclusion that the existing systematic reviews and meta-analyses did not provide adequate scientific base in all aspects of critical care and that tele-ICU research should involve multiple clinical and scientific disciplines [38, 39].

In conclusion, to recommend tele-ICU as a way forward in geriatric patients, many of the above aspects have to be placed into perspective. The implementation of tele-ICU would depend on individual healthcare policies of their own country and budget. The clinical benefits have been evidenced from a mix of various types of tele-ICU models, and an ideal tele-ICU model would be dependent on the type of patient mix admitted in the various ICUs and the clinical/hospital setting. More studies need to be undertaken with specific issues as far as geriatric patients are concerned. It is likely that tele-ICU will progress further in the coming years, will fulfill the present gaps, and will be applied to provide safe and effective critical care delivery to the aging population requiring this option.

Conflict of interest All of the authors have no conflicts of interests.

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