Advanced hemodialysis technologies are needed to improve ESKD care in Asia

Asia is heterogenous…

	Afghanistan	Laos	China	India	Singapore	Japan
GDP per capita (nominal; US$)[1]	470	1,320	5,430	1,489	46,241	45,903
Total Health Expenditure per capita (US$)	15	39	191	44	1,531	3,754

At < US$60 per capita, difficult to deliver reasonable minimum services (WHO, 2000)

World Development Indicators 2011
World Health Statistics 2012

What are the challenges to improve ESKD care in Asia?

- There is a large (and increasing) unmet need of dialysis
- Removal of financial barrier increases uptake/initiation on dialysis
- Dialysis population is younger, often family breadwinners
- Shortage of trained healthcare personnel
- Residual inequities around dialysis initiation need addressing
- New models of care and care delivery might worsen inequity unless addressed specifically
- Re-conceptualize understanding of health: refocus on prevention, early detection

Variations in ESKD care practice

- Warranted : patient preference, underlying conditions
- Unwarranted:
  - Effective care – based on clinical evidence
  - Preference-sensitive care – patients exercising choice between available valid treatment options
  - Supply-sensitive care – different availability of treatment(s)

https://www.healthknowledge.org.uk/public-health-textbook/research-methods/1c-health-care-evaluation-health-care-assessment/equity-health-care

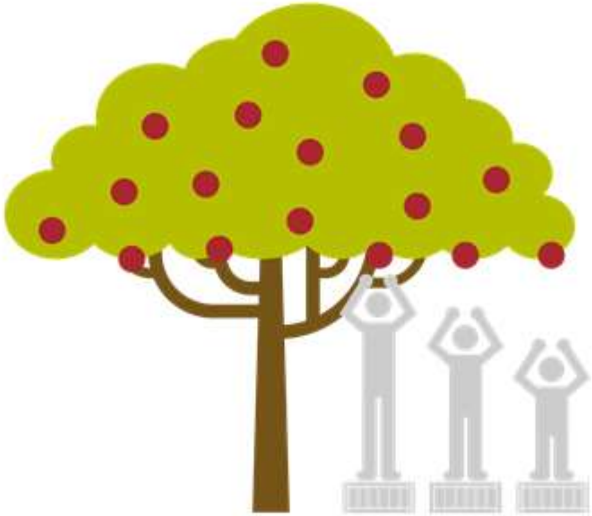
FAIR ISN'T

everybody getting the same thing.......

FAIR IS

everybody getting what they need in order to be

SUCCESSFUL.



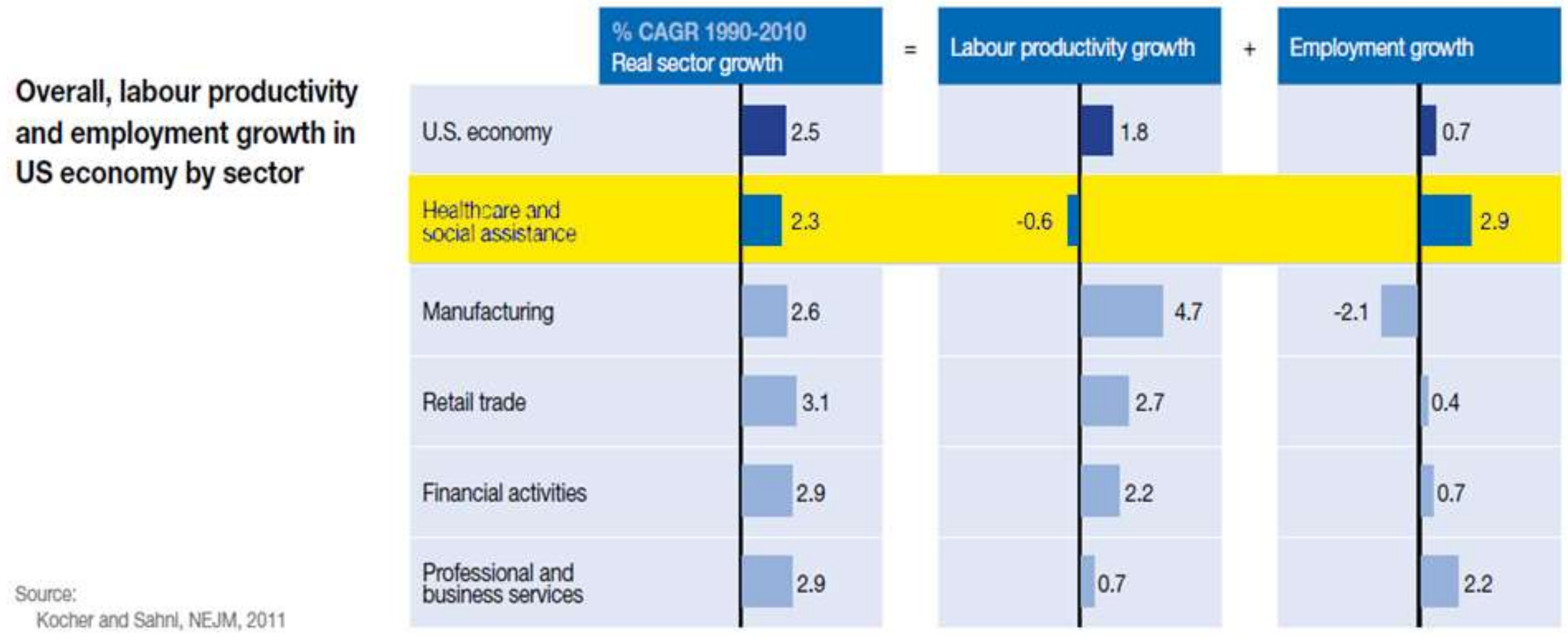
Equality sounds fair.

Equity IS fair.

Aims of dialysis

- Replace the function of the failed kidneys as completely as possible
- Full rehabilitation of the patient
- Minimal cost to society

Labor Productivity



If developing world uses current models, there will never be enough trained personnel for rising demand

Technology

("science of craft", from Greek τέχνη, techne, "art, skill, cunning of hand"; and -λογία, -logia) is the collection of techniques, skills, methods, and processes used in the production of goods or services or in the accomplishment of objectives, such as scientific investigation.


make
TECHNOLOGY
work for you

The machines rose from the ashes of the nuclear fire. Their war to exterminate mankind had raged for decades, but the final battle would not be fought in the future. It would be fought here, in our present.

The machines are willing!

Advanced HD technologies

- Increase in dialysis dosage
- Preference of high-flux versus low-flux membranes
- Choice between convection and diffusion as dialysis strategy
- Chemical composition and biologic purity of dialysate
- Effect of sodium, potassium, volume profiling
- Intradialytic volume monitoring aiming at improving hemodynamic stability

Lameire et al CJASN 2009

Dialysis dosage

Membrane flux

- Membrane Permeability Outcome (MPO) study
  - 37% survival benefit
  - Improved survival in those with diabetes
  - No benefit if albumin >4 g/dl

- HEMO Study
  - β_2-microglobulin clearance <10 and >20 ml/min
  - No survival difference in primary analysis
  - Reduced risk of cardiac death and cardiac hospitalizations, CVA and those on dialysis for >3.7 y
  - Favourable effect on infection-related mortality/morbidity

- 4D Study
  - High flux dialysis better in diabetics

Modeling

- Sodium
- Potassium
- Temperature control

Dialysate purity

- No studies to show beneficial direct outcomes by using ultrapure water and/or dialysate
- European and Japanese criteria more stringent than those in the United States
- Reduces the microinflammatory state of the patients

Convective v diffusive therapies

- Convective therapies
  - enhance removal of large solutes
  - require large volumes of substitution fluid as well as sophisticated volume control systems
- Hi-eff online HDF has better morbidity profile
  - hypotension incidence, better BP control, improved hemocompatibility, reduced inflammation profile, improved lipid profile, improved anemia correction, reduced incidence of β_2-microglobulin amyloidosis, and hospitalization
- HDF provides mortality benefit

ClinicoEconomics and Outcomes Research

Dovepress
open access to scientific and medical research

Open Access Full Text Article

ORIGINAL RESEARCH

Cost-effectiveness analysis of online hemodiafiltration versus high-flux hemodialysis

This article was published in the following Dove Press journal:
ClinicoEconomics and Outcomes Research
22 September 2016

Technical Innovations in Hardware and Software

- Plug-and-play features
- Improved safety
- Fewer human errors
- Reduced labour cost
- Helps in situations of manpower shortage

Other technologies

Registry name (common abbreviation), year of establishment	Accessibility	Patient-level data availability	Treatments	Out-comes
Hong Kong Renal Registry (HKRR), 1995	+	+	+++	+++
Korean Renal Registry, 1985	++	++	+++	+++
Malaysian National Renal Registry (NRR), 1993	++	+++	+++	+++
Shanghai Dialysis Registry, 1996	+	+	++	+++
Singapore Renal Registry, 2001	+++	++	+++	+++
Taiwan Renal Registry Data System (TWRDS), 1987	+	+	+++	+
Thailand Renal Replacement Therapy Registry (TRT), 1997	++	+	+++	+

Accessibility: +++ (good): information including annual reports, publications and aggregate data accessible via website, publicly available records, or with assistance from registry staff. ++ (moderate): information in local language only or limited publicly available information including on website; with additional searches, basic information may be available in reports or in published research; more information may be accessible via third-party collaborators (e.g. registry researchers or local academics). + (limited/unclear): very limited information available publicly or unclear.

Patient-level data availability: +++: available to external researchers directly or through application and review; may include usage fee. ++: conditional access, e.g. via third-party collaborators. +: not available to external researchers or access process unclear.

Treatments: +++: submodality available. ++: modality available but not submodality. +: modality not available or availability unclear.

Outcomes: +++: mortality/survival and/or hospitalization/complication data available. ++: mortality/survival or hospitalization/complication data not reported; surrogates such as laboratory result data reported. +: no reported outcome or surrogate data or availability unclear.

Prasad, Jha, Kidney Diseases 2015


RMM
Dashboard: Monitoring
Devices
143
Problem devices
102
Daily safety check problems
29
24x7 check problems
44
Problem servers
78
Server status
Problem workstations
15
Workstations status
Device types
143
Devices by main OS
143
Last reboot time
Patch Management install status
Managed Antivirus install status
Backup install status
Web Protection install status

Non-contact vital sign monitoring in the clinic

Mauricio Villarroel[1], João Jorge[1], Chris Pugh[2] and Lionel Tarassenko[1]
[1] Institute of Biomedical Engineering, Department of Engineering Science, University of Oxford, UK
[2] Nuffield Department of Medicine, University of Oxford, UK

***Abstract*— Current monitoring systems available to track changes in the vital signs of patients (such as heart rate, respiratory rate or peripheral oxygen saturation) require contact with the subject. Most patients requiring regular monitoring find the probes difficult to wear over prolonged periods of time. Research in non-contact vital sign monitoring has recently expanded through the use of off-the-shelf video cameras; nevertheless, most of the current work in video-based non-contact vital sign monitoring has so far been performed over short time periods (typically up to a couple of minutes), under tightly controlled conditions with relatively still and healthy volunteer subjects.**

Using an off-the-shelf camera, we have been able to compute estimates of heart rate and respiratory rate, and also detect changes in peripheral oxygen saturation in a real hospital scenario, without interfering with regular patient care. Videos were recorded for 369.1 hours from 40 patients undergoing haemodialysis treatment in the Renal Unit of the Churchill Hospital in Oxford, UK. The mean absolute error between the heart rate estimates from the camera and the average from two reference pulse oximeters (positioned at the finger and earlobe respectively) was 2.8 beats per minute for over 65% of the time, which was comparable to the error between the two reference pulse oximeters. The mean absolute error between the respiratory rate estimates from the camera and the reference values (computed from the Electrocardiogram and a thoracic expansion sensor - chest belt) was 2.1 breaths per minute for over 69% of the time for which the reference signals were valid. By calibrating the camera data with the reference pulse oximeters, changes in peripheral oxygen saturation could also be tracked during time periods with minimal patient motion.

I. INTRODUCTION

The measurement of the standard vital signs such as heart rate (HR), respiratory rate (RR), peripheral oxygen saturation (SpO_2), blood pressure and temperature is a core component of the physical assessment of most patients [1]. Of these vital signs, heart rate, respiratory rate and SpO_2 are of main interest for this paper.

Heart rate is a measure of the rate at which the heart beats. An appropriate monitoring of the heart's pumping mechanism is of vital importance as with each heart beat, blood is sent throughout the body carrying gases, nutrients, hormones and other substances used in metabolic processes by the cells [2].

Respiratory rate is recognised as an important vital sign since it has been found to be predictive of lower respiratory tract infections [3], the evaluation of the severity of pneumonia [4], a risk factor for unplanned hospital readmissions [5] and mortality risk assessment for paediatric patients in intensive care units [6].

Oxygen is a chemical substance essential to the functioning of each cell in the human body and, therefore, necessary to sustain life. It is important to monitor if organs are receiving a sufficient supply of oxygen as it is being delivered to all the body parts. The measurement of blood oxygenation, also known as oxygen saturation, is an important indicator of a patient's health. A prolonged lack of oxygen can rapidly cause permanent damage to cell tissue, leaving patients with devastating neurological handicaps and has the potential to be life-threatening, if cells having high metabolic rate in organs such as the brain, heart or the central nervous system are damaged [2], [7].

Conventional patient monitoring systems require a probe to be attached to the patient, such as the finger or ear in a pulse oximeter or on the chest in an Electrocardiogram (ECG) monitor. These have the potential to cause skin irritation, increasing the risk of infection and increasing the costs of implementing and maintaining new technology. The ideal technology to estimate vital signs would involve sensors with no direct contact with the patient ("non-contact sensing"). This paper proposes algorithms for the remote monitoring of heart rate, respiratory rate and identifying changes in SpO_2 using a standard colour camera and ambient light.

The paper is organised as follows. A summary of the clinical study is presented in the next section, followed by the description of the proposed methods for non-contact vital sign monitoring. Subsequently, the evaluation of these algorithms against the reference signals are presented. Finally, the paper ends with a discussion of the applicability of non-contact vital sign monitoring in the clinic.

II. CLINICAL STUDY

The dataset for this paper was recorded from patients undergoing haemodialysis treatment in the Renal Unit of the Churchill Hospital in Oxford. The research application was submitted to the Oxford University Clinical Trials

MV was supported by the Oxford Centre of Excellence in Medical Engineering funded by the Wellcome Trust and EPSRC under grant number WT 88877/Z/09/Z. The clinical study in the Oxford Kidney Unit was funded by the NIHR Biomedical Research Centre Programme, Oxford. JJ was supported by the RCUK Digital Economy Programme grant number EP/G036861/1 (Oxford Centre for Doctoral Training in Healthcare Innovation) and the Fundação para a Ciência e Tecnologia, Portugal, doctoral grant SFRH/BD/85158/2012. We would like to thank all the patients from the Oxford Kidney Unit who agreed to take part in the clinical study, as well as Dr David Meredith and Mr Sheera Sutherland who carried out the study.

978-1-5090-4023-0/17/$31.00 ©2017 IEEE

Other aspects of dialysis

- Timely referral to a nephrologist
- Quality and types of vascular access
- Holistic medical, social, and psychological preparation for dialysis
- Implementation of good clinical practice guidelines
- Attention to total clinical care by the dialysis team
- Tailor therapy to patient preference and the local circumstances

- Evaluate new technologies more thoroughly and critically
- New devices should never substitute sound clinical judgment

What should we prioritise?

- Provide value-based care
- Get insight from information
- More home dialysis