A COMPARISON OF EQUIPMENT DISPOSAL PATTERN WITH LIFESPAN CALCULATED FROM DEPRECIATION

Binseng Wang – Sodexo HTM
Torgeir Rui - Sodexo HTM

MDEXPO
Las Vegas • April 7-9, 2024

Discovering the Possibilities

Discovering the Possibilities

ABOUT THE SPEAKERS: BINSENG WANG

- Binseng Wang is a vice-president with Sodexo HTM, an independent medical equipment service organization located in the USA.
- Previously, Dr. Wang was Director, Quality & Regulatory Affairs for Greenwood Marketing LLC, Vice President, Quality & Regulatory Affairs, for Sundance Enterprises, Aramark Healthcare Technologies, and MEDIQ/PRN. He also worked as a Visiting Scientist at NIH, Adjunct Professor at the Milwaukee School of Engineering, and Associate Professor at Univ. of Campinas, Brazil.
- He is a fellow of ACCE and AIMBE. He received the 2010 AAMI CE Achievement Award, the 2015 ACCE Lifetime Achievement Award and the 2019 AAMI-TRIMEDX Iconoclast award. He was inducted into the Clinical Engineering Hall of Fame by ACCE in 2017 and granted the title of Honorary Life Member by the Int'l Federation of Medical & Biological Eng. (IFMBE) in 2022. He was chair of ACCE International Committee 2018-2023.
- He earned a Doctor of Science degree from MIT and is a Certified Clinical Engineer (CCE).

Binseng Wang, ScD, CCE

ABOUT THE SPEAKERS: TORGEIR RUI

- Torgeir Rui is a lead data analyst with Sodexo HTM, an independent medical equipment service organization.
- He has held various research and development roles in logistics automation, healthcare, healthcare technology management, electric power, and automotive industries.
- He earned a Sivilingeniør (M.Sc.Eng. equivalent) degree from the Norwegian University of Science and Technology.

Torgeir Rui, siv.ing

CONTENTS

- INTRODUCTION
  - Why study equipment disposal pattern and lifespan?
  - Prior studies/recommendations
  - Summary of our prior study results
- METHODOLOGY
  - Data source & analysis
- RESULTS
  - Disposal pattern
  - Lifespan estimation
- DISCUSSION
- CONCLUSIONS

INTRODUCTION

- Why study disposal pattern and lifespan? => Because they can help:
    - Maintenance planning
        - Some equipment exhibit aging (increasing repairs with age) => increasing labor & parts
        - Some equipment can continue to be deploy beyond depreciation and lifespan estimates but must secure parts and labor beyond OEM's EOL/EOS dates
    - Replacement planning
        - Some equipment should be replaced sooner if maintenance costs > xx% replacement cost or fair-market price
        - Some replacement may not need advanced planning, only on a "contingency" basis
        - Most equipment likely last beyond depreciation and lifespan estimates
        - Some older equipment can be retained as back-ups for emergencies and sudden census peaks
    - BOTTOM LINE: Can reduce capital inve$tment and improve "bottom line"

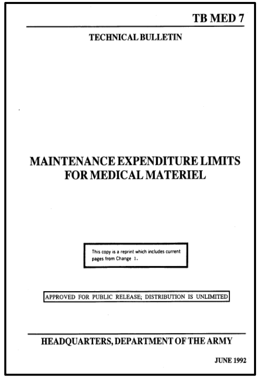
INTRODUCTION

- Prior studies/recommendations (mixture of financial and technical considerations, i.e., depreciation & expert opinion)
  - AHA's *Estimated Useful Lives of Depreciable Hospital Assets*
  - US Army: Maintenance Expenditure Limits for Medical Materiel - TB MED 7)
  - VHA: equipment life expectancies (Medical Device Nomenclature System – VAMDNS & Medical Equipment Management Guidebook)
  - ECRI: expected useful lives (Biomedical Guide)


Estimated Useful Lives of Depreciable Hospital Assets

Revised 2018 Edition

American Hospital Association


TB MED 7

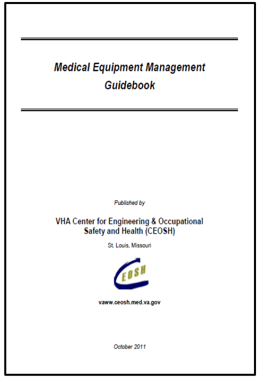
TECHNICAL BULLETIN

MAINTENANCE EXPENDITURE LIMITS FOR MEDICAL MATERIEL

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED

HEADQUARTERS, DEPARTMENT OF THE ARMY

JUNE 1992


Medical Equipment Management Guidebook

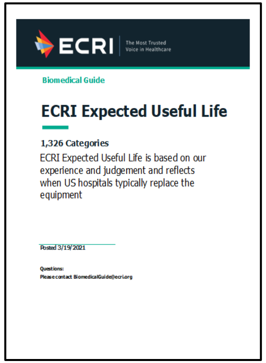
Published by

VHA Center for Engineering & Occupational Safety and Health (CEOSH)

St. Louis, Missouri

vaww.ceosh.med.va.gov

October 2011


ECRI The Most Trusted Voice in Healthcare

Biomedical Guide

ECRI Expected Useful Life

1,326 Categories

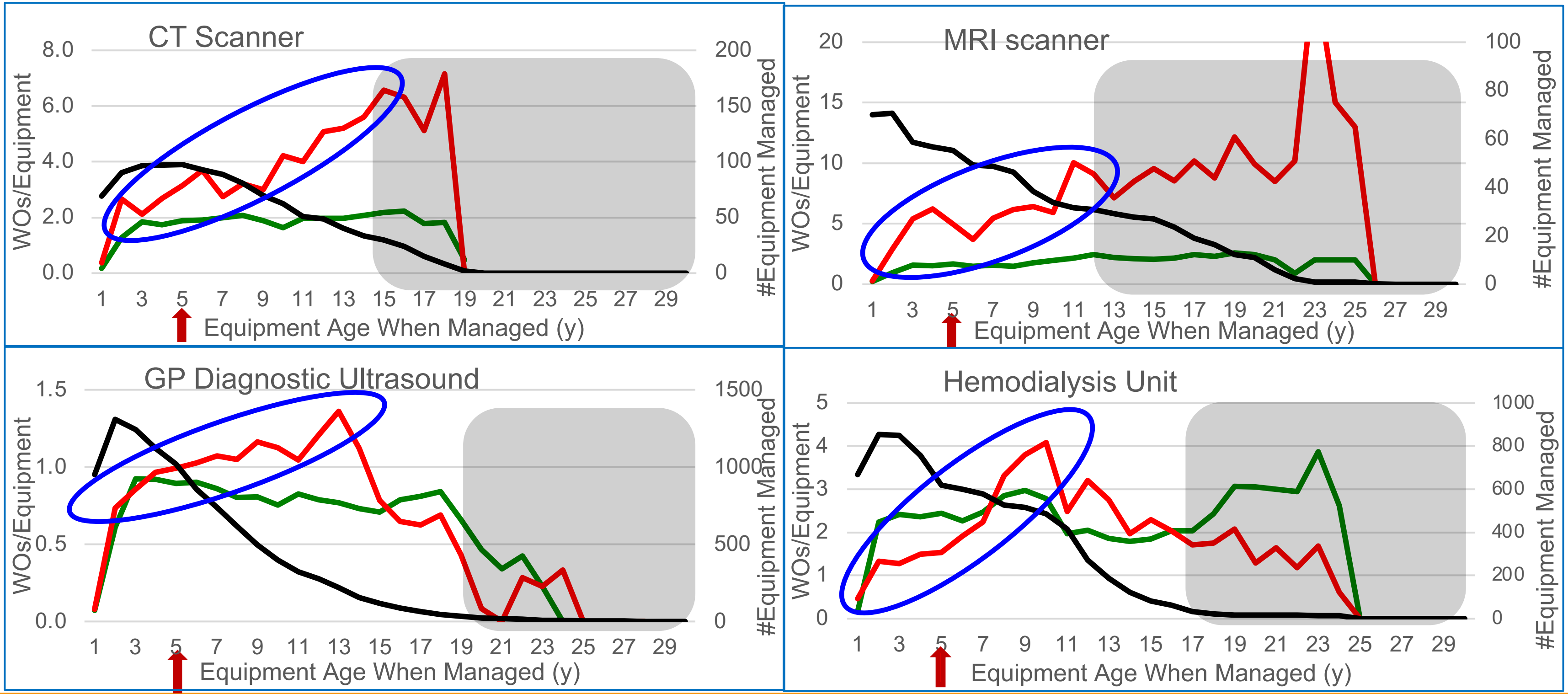
ECRI Expected Useful Life is based on our experience and judgement and reflects when US hospitals typically replace the equipment

SUMMARY OF OUR PRIOR STUDY RESULTS

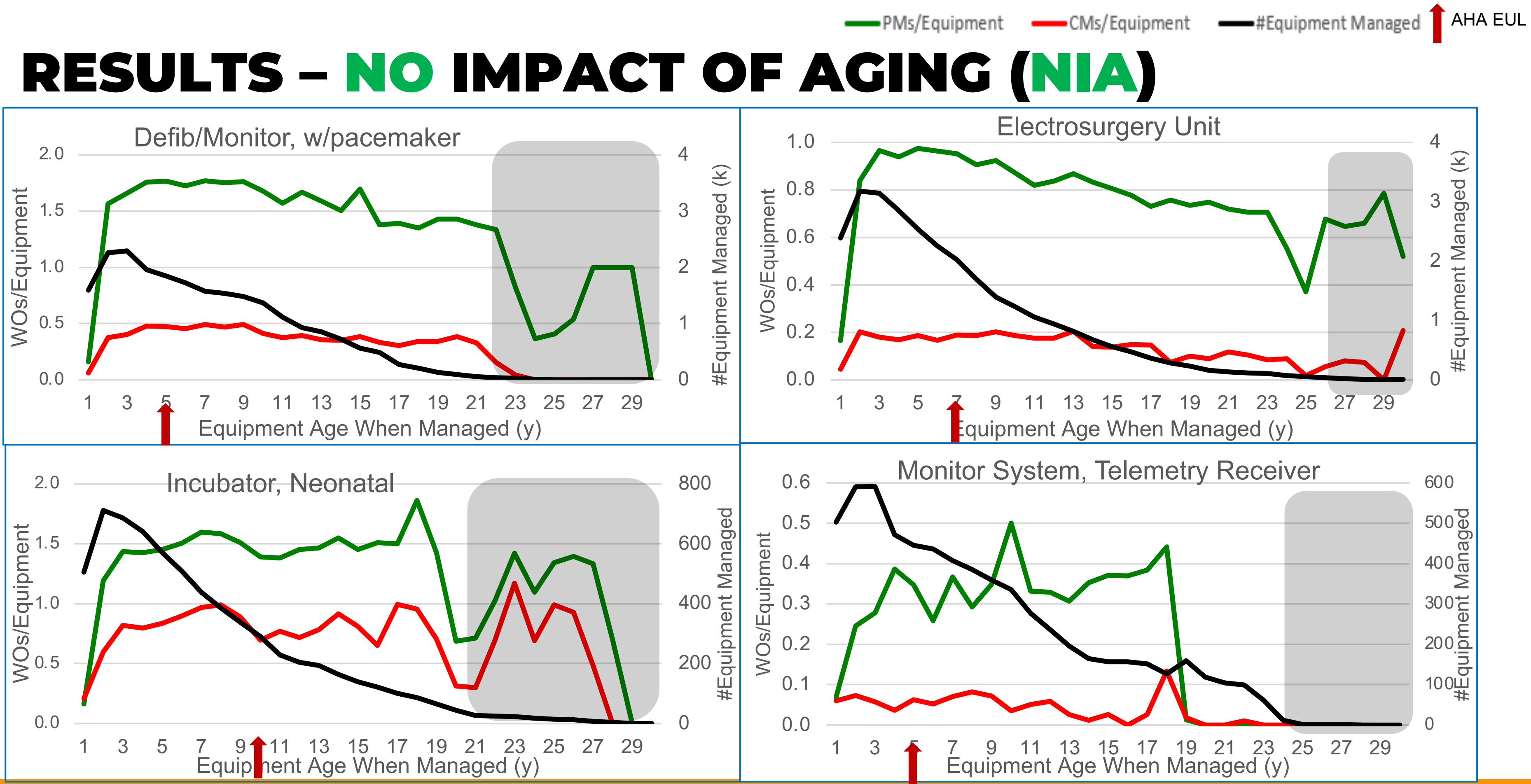
(presented at the Oct 2023 MD Expo in Orlando)

- Equipment aging can be divided into 3 categories
  - Clear impact of aging (CIA): visible increase of CMs/equipment with age
  - No impact of aging (NIA): invisible increase of CMs/equipment with age
  - Inconclusive impact of aging (IIA): unclear increase of CMs/equip-ment with age => further study needed to reclassify into CIA or NIA.
- **NOTE**: Equipment was group by type (function) regardless of brand/model because of limited amount of data available and data quality concerns at brand/model level => further studies will be conducted at brand/model level.

RESULTS – CLEAR IMPACT OF AGING (CIA)

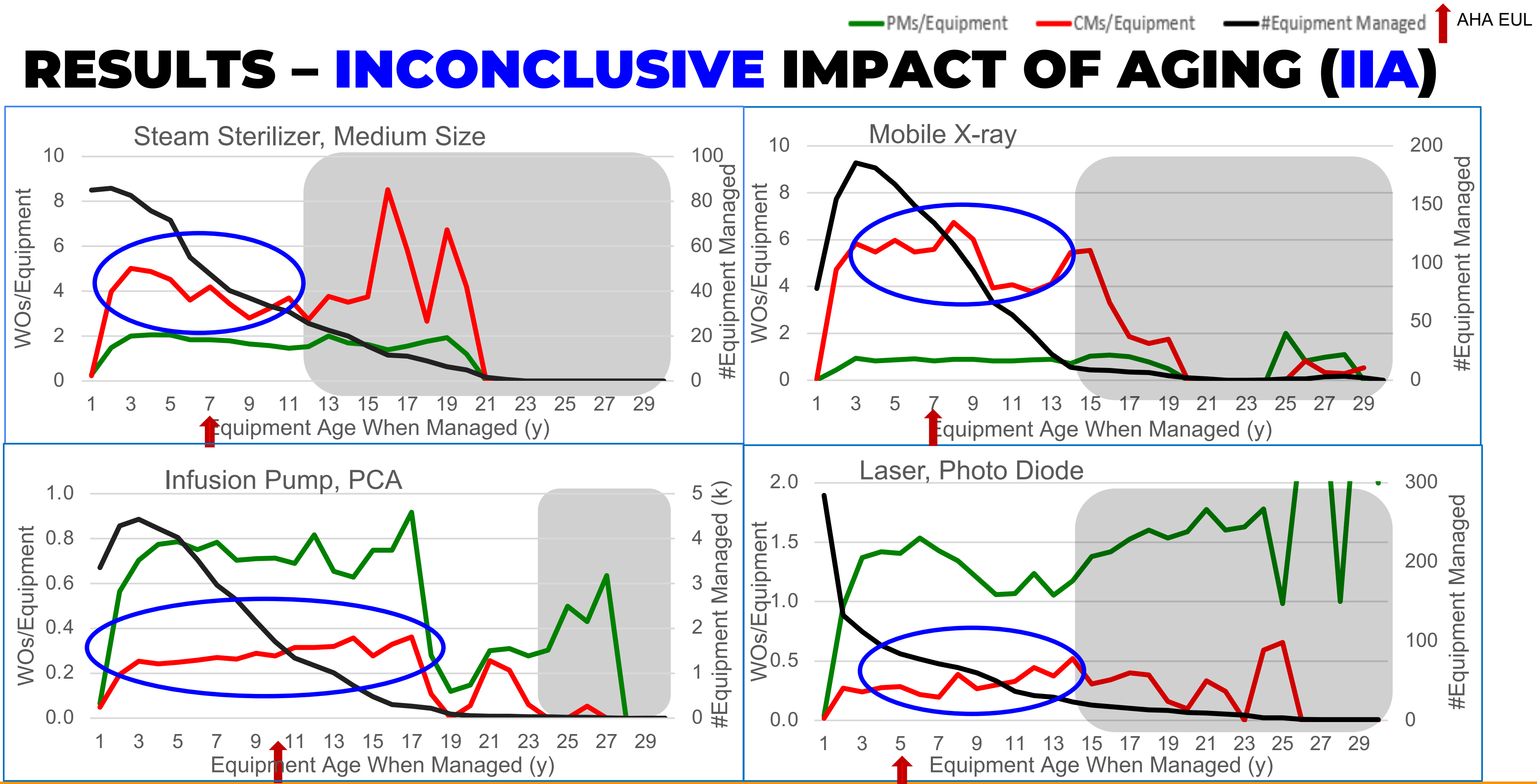


RESULTS – NO IMPACT OF AGING (NIA)



Discovering the Possibilities

RESULTS – INCONCLUSIVE IMPACT OF AGING (IIA)



CONTENTS

METHODOLOGY

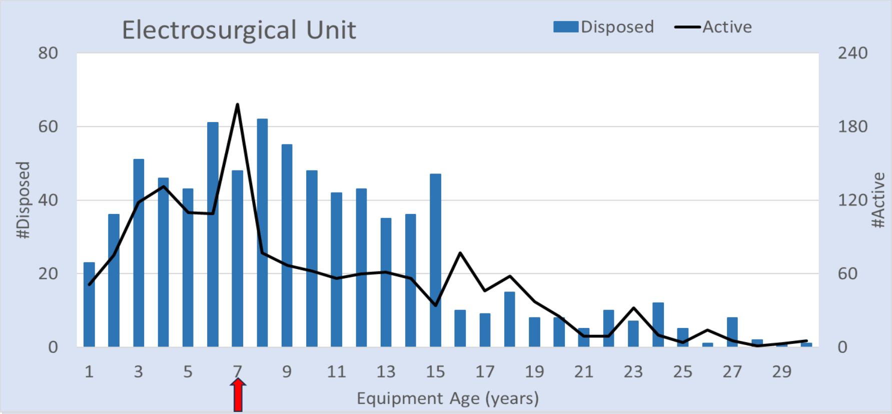
- **Data**
  - **Data Source**: ~342,000 pieces of equipment belonging to >100 Sodexo HTM hospital clients, managed 30+ years. This is only a portion (~57%) of the inventory and service history due to data quality issues.
  - **Equipment Age (EA)**: year manufactured or acquired/installed
- **Analyses**
  - Histogram of active and disposed equipment (analogous to alive and demised humans) versus EA
  - Estimated life expectancy (ELE) at purchase/installation (analogous to life expectancy at birth) – for comparison with AHA's estimated useful life (EUL), VHA's life expectancy (LE), and ECRI's expected useful life (ExUL)

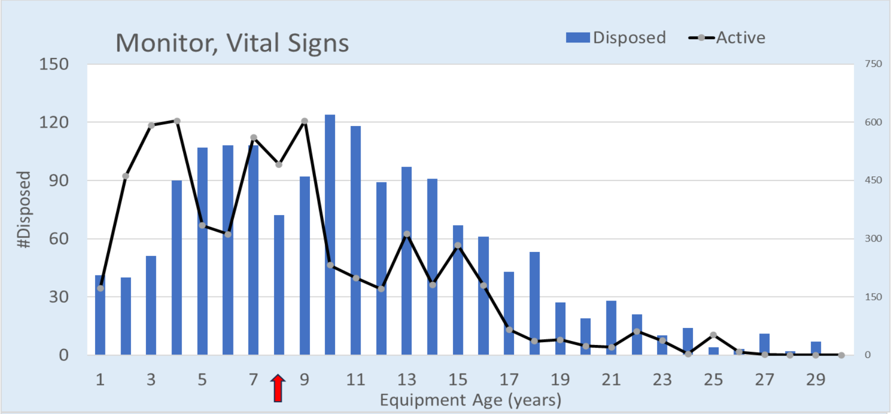
METHODOLOGY (cont.)

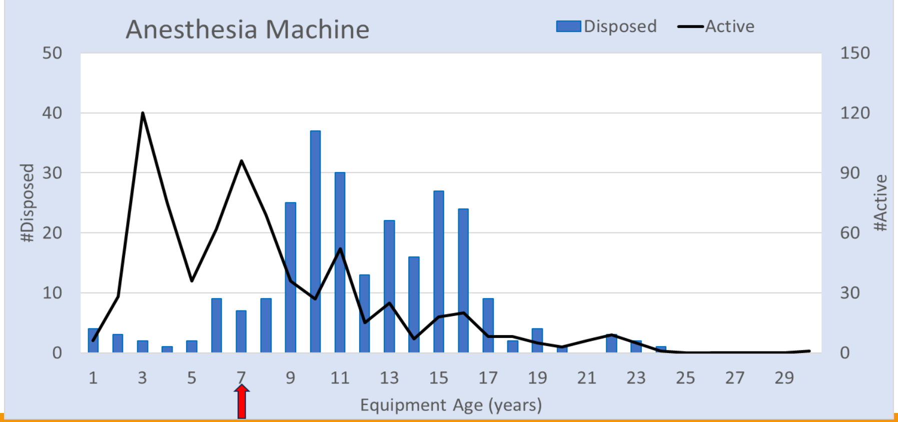
GROUP	EQUIPMENT TYPE	GROUP	EQUIPMENT TYPE	GROUP	EQUIPMENT TYPE	GROUP	EQUIPMENT TYPE
Biomed	Continuous passive motion machine	Biomed	Neonatal incubator	Surgical	Blood warmer, surgical	DI	Diagnostic US, point of care
	Defib/monitor w/pacemaker		Neonatal warmer		Electrosurgical unit		Digital mammography unit
	Electric bed		Pt lift		Heart lung bypass system		Mobile C-arm
	Heart lung bypass system		Pt monitor, multiparameter		Image guided surgical system		Mobile X-ray
	Hemodialysis machine		Pulmonary function system		Multi-gas anesthesia monitor		MRI scanner
	Hypo/hyperthermia machine		Pulse oximeter		Robotic surgical system		Nuc Med camera
	Infusion pump, controller		Sequential compression device		Steam sterilizer, medium		PACS work station
	Infusion pump, feeding		Stretcher		Surgical light, ceiling mounted		Radiology flat panel detector
	Infusion pump, modular		Telemetry monitor receiver station		Surgical table		Ultrasonic bladder scanner
	Infusion pump, multi-channel		Telemetry transmitter		Waste management system	Lab	Blood gas/pH analyzer
	Infusion pump, PCA		Therapeutic ultrasound	DI	Bone density scanner		Chemistry analyzer
	Infusion pump, single channel		Ventilators (w/o compressors)		Contrast injector, angiographic		Coagulation analyzer
	Infusion pump, syringe		Vital signs monitor		CT scanner (33-128 slices)		Hematology analyzer
	Intra aortic balloon pump	Surg	Anesthesia machine		Diagnostic US, cardiac		Refrigerated centrifuge
	Multichannel ECG		Autotransfusion unit		Diagnostic US, general purpose		Table-top centrifuge

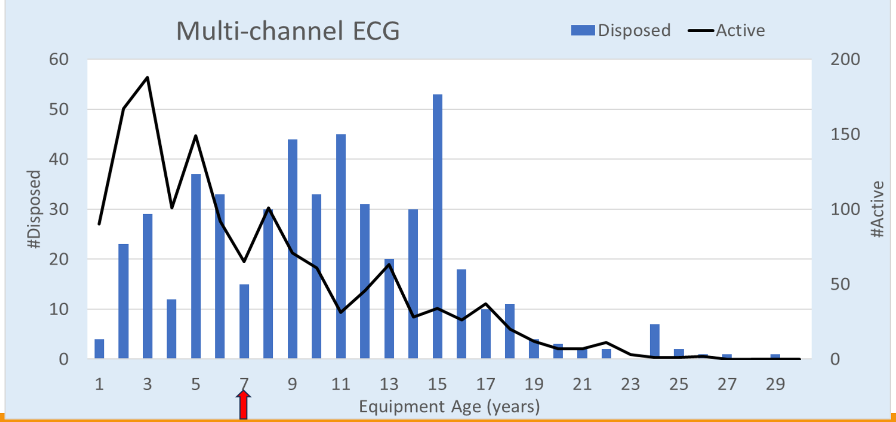
AHA EUL

RESULTS – GRADUAL DISPOSAL

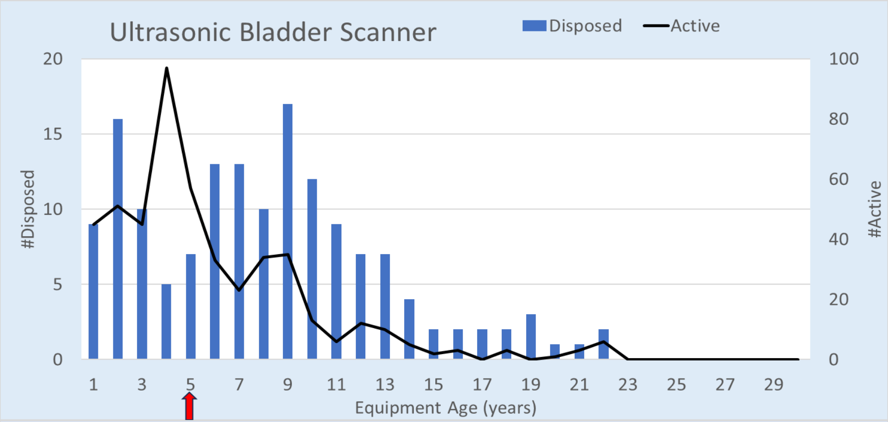


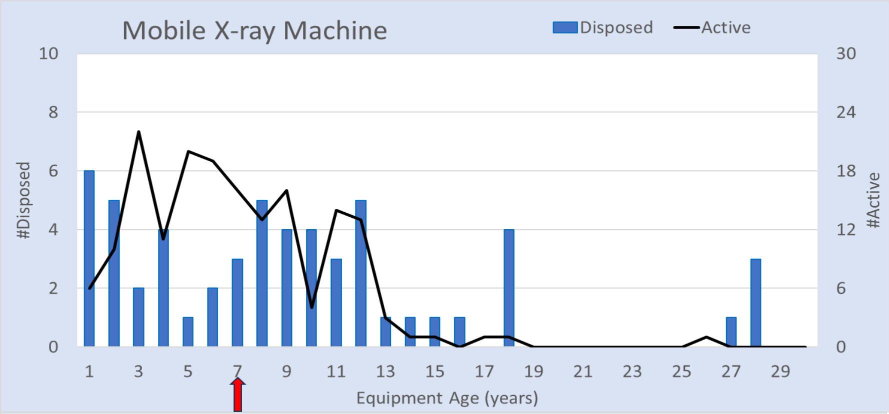


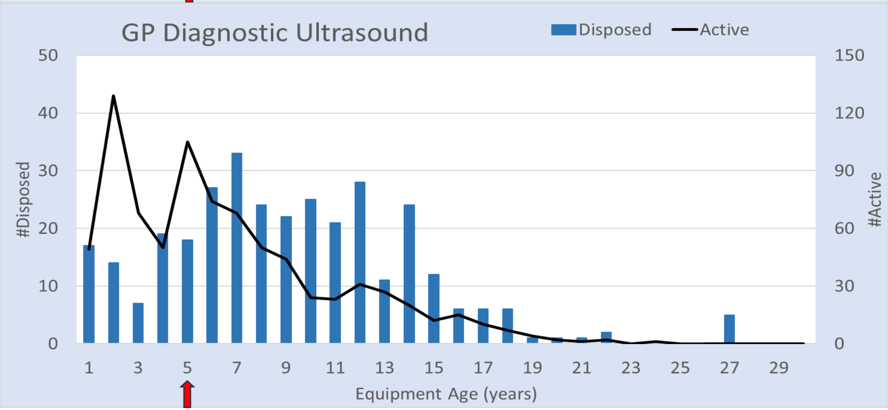


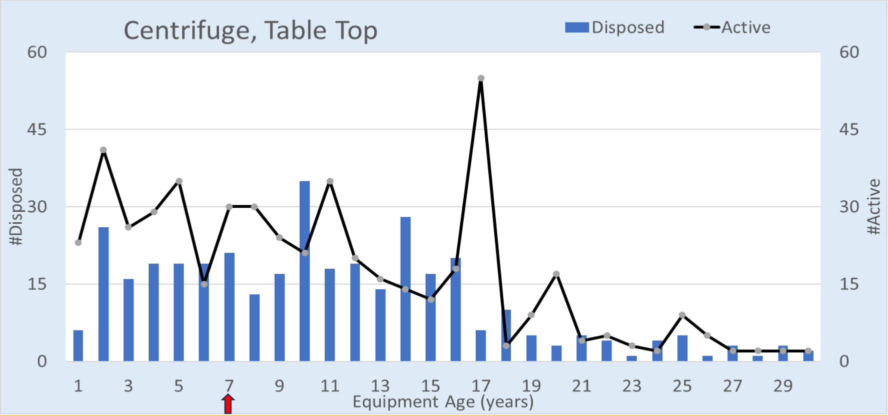


RESULTS – GRADUAL DISPOSAL



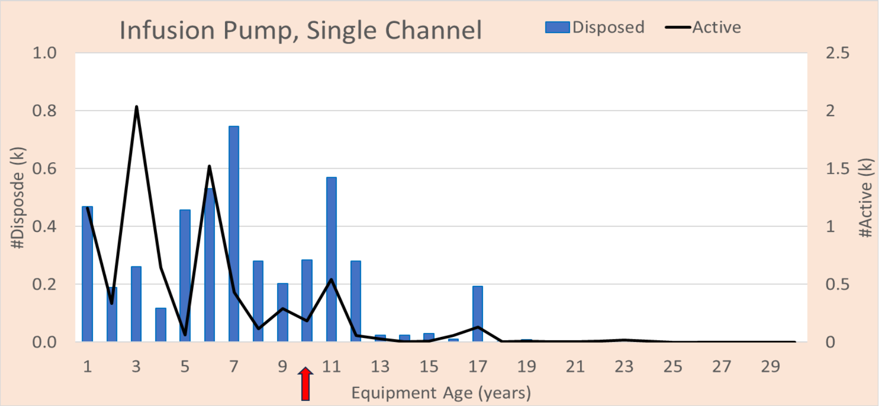


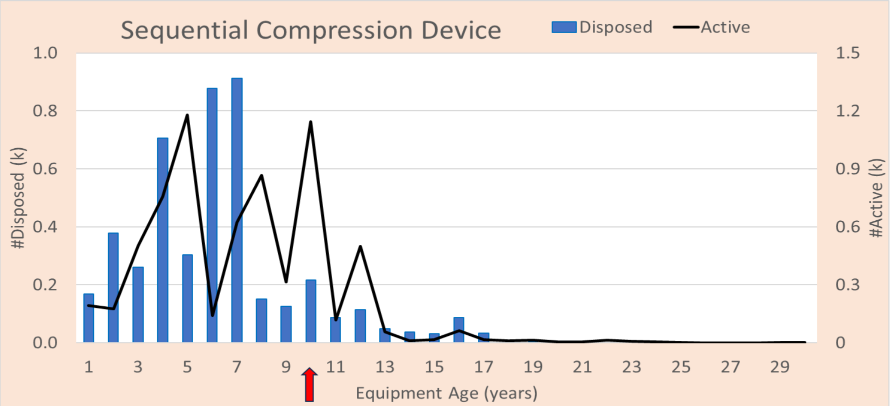


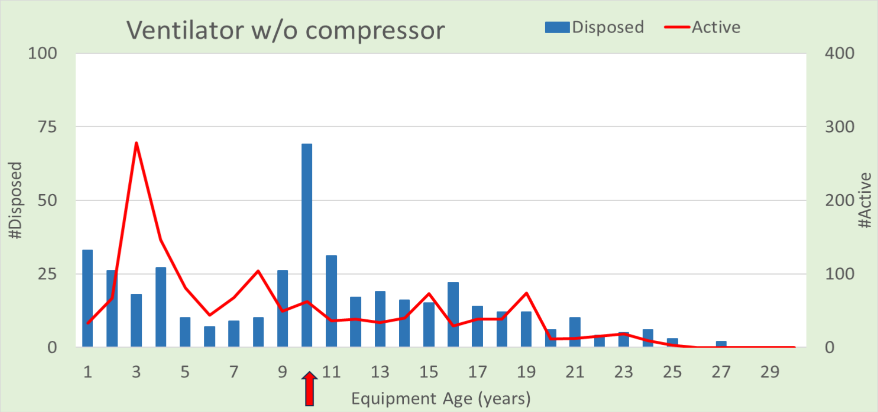


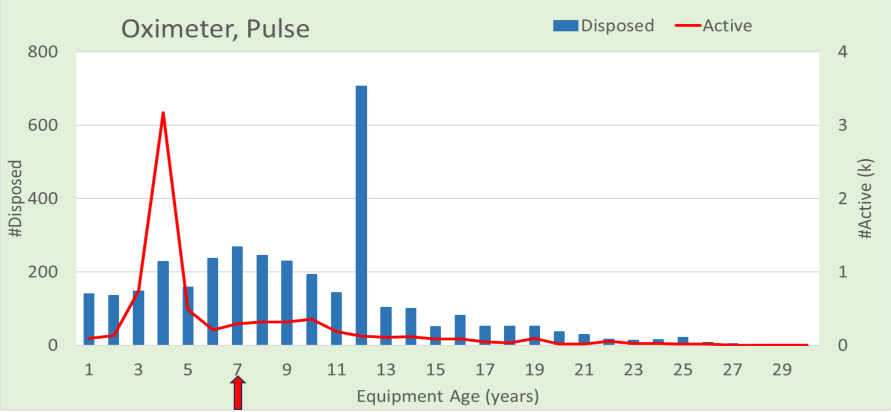
RESULTS – GROUP DISPOSAL & ACQUISITION

AHA EUL









METHODOLOGY – ELE Calculation

- **Human life expectancy**
  - Human life expectancy is an estimate of average remaining years of life at a certain age. A common measure is the life expectancy at birth.
  - (Period) life expectancy at birth is the average length of life for a hypothetical population that experiences observed mortality rate from birth through death (without considering future changes to mortality rate).
- **Life expectancy is calculated using a "life table" which is constructed in this manner**
  - Start with 100,000 simultaneous births (l_0) and assume the maximum lifespan is 110 years
  - The #survivors reaching age 1 (l_1) = l_0 - #deaths at age 0 (d_0), or $l_1 = l_0 - d_0$. The same calculation goes on for age 2, 3, etc., i.e., $l_{x+1} = l_x – d_x$, where #deaths at age x (d_x) = #survivors at age x (l_x) multiplied by mortality rate between age x and age x+1 (q_x) or $d_x = l_x * q_x$
  - Mortality rate (q_x) is calculated from the "central mortality rate" (m_x), i.e., total #deaths in 3 years and the total mid-year population in those 3 years (see details in link)
  - Life expectancy (e_x) at age x is total number of years lived from age x (T_x) divided by the number of survivors (l_x) at age x, i.e., $e_x = T_x/l_x$.
  - Life expectancy at birth is denoted e_0.

METHODOLOGY – ELE Calculation (cont.)

- **Modifications made for equipment life expectancy (ELE) from human life expectancy calculation**
  - Different age span: ages 0-30
  - Infant (age 0-1) disposal rate not calculated differently from other ages (1-30)
  - Not split by gender or race (but by equipment type)
  - Mortality calculation period increased from typical 1 or 3 years to last 5 years (to increase data set)
  - Imposed exclusion criteria for those equipment types with low number of covered equipment, disposals or early spikes in disposal rates

Human LE Term	Equipment LE Term
Birth	Acquisition (or manufacture)
Death	Disposal (Retire)
Mortality Rate	Disposal Rate
Survivor	Active
Age (years from birth)	Age (years from acquisition or manufacture)

LIFE TABLE – Electric Beds

Age	Disposal Rate (q_x)	Central Rate of Disposal (m_x)	Active (l_x)	Disposals (d_x)	Life Expectancy (e_x)	Age	Disposal Rate (q_x)	Central Rate of Disposal (m_x)	Active (l_x)	Disposals (d_x)	Life Expectancy (e_x)
0	0.00000	0.00000	100000	0	19.5	16	0.03500	0.03562	67937	2378	7.7
1	0.00565	0.00567	100000	565	18.6	17	0.04399	0.04498	65559	2884	7.0
2	0.00000	0.00000	99435	0	17.6	18	0.01681	0.01695	62675	1054	6.1
3	0.00836	0.00840	99435	831	16.7	19	0.00686	0.00689	61621	423	5.1
4	0.03445	0.03506	98603	3397	16.3	20	0.04531	0.04636	61199	2773	4.3
5	0.00811	0.00815	95206	772	15.4	21	0.26403	0.30419	58426	15426	4.5
6	0.00987	0.00992	94434	932	14.5	22	0.10120	0.10660	42999	4352	3.7
7	0.01035	0.01041	93501	968	13.7	23	0.46192	0.60064	38648	17852	4.9
8	0.01271	0.01279	92533	1176	12.8	24	0.03538	0.03602	20796	736	3.6
9	0.00000	0.00000	91357	0	11.8	25	0.17792	0.19530	20060	3569	3.2
10	0.02459	0.02490	91357	2246	11.1	26	0.00000	0.00000	16491	0	2.0
11	0.02822	0.02862	89111	2515	10.4	27	0.55225	0.76291	16491	9107	2.3
12	0.08738	0.09137	86596	7567	10.3	28	0.91136	1.67431	7384	6729	8.1
13	0.03230	0.03283	79029	2553	9.5	29	0.00000	0.00000	654	0	2.0
14	0.08031	0.08367	76477	6142	9.2	30	0.00000	0.00000	654	654	1.0
15	0.03409	0.03469	70335	2398	8.5						

RESULTS – ELE vs EUL, LE & ExUL

GROUP	EQUIPMENT TYPE	AHA EUL	VHA LE	ECRI ExUL	ELE	GROUP	EQUIPMENT TYPE	AHA EUL	VHA LE	ECRI ExUL	ELE
Biomed	Continuous passive motion machine	10	11	10	22	Biomed	Neonatal warmer	10	9	7	18
	Defib/monitor w/pacemaker	5	6	7	14		Pt lift	10	10	10	21
	Electric bed	12	12	15	19		Pt monitor, multiparameter	7	9	8	16
	Heart lung bypass system	8	8	10	13		Pulmonary function system	8	11	8	13
	Hemodialysis machine	5	8	10	19		Pulse oximeter	7	8	7	13
	Hypo/hyperthermia machine	10	11	10	15		Sequential compression device	10	6	7	15
	Infusion pump, controller	10	9	10	13		Stretcher	15	10	10	18
	Infusion pump, feeding	10	8	10	21		Telemetry monitor receiver station	5	9	8	13
	Infusion pump, modular	10	8	10	20		Telemetry transmitter	5	9	8	13
	Infusion pump, multi-channel	10	8	10	13		Therapeutic ultrasound	7	12	8	18
	Infusion pump, PCA	10	8	10	14		Ventilators (w/o compressors)	10	7	10	16
	Infusion pump, single channel	10	8	10	11		Vital signs monitor	8	9	8	19
	Infusion pump, syringe	10	8	10	22	Surg	Anesthesia machine	7	8	10	17
	Intra aortic balloon pump	7	6	8	18		Autotransfusion unit	6	8	8	14
	Multichannel ECG	7	8	10	16		Blood warmer, surgical	7	8	8	11
	Neonatal incubator	10	7	7	16		Electrosurgical unit	7	8	7	16

RESULTS – ELE vs EUL, LE & ExUL (cont.)

GROUP	EQUIPMENT TYPE	AHA EUL	VHA LE	ECRI ExUL	ELE
Surg	Heart lung bypass system	8	8	10	12
Surg	Image guided surgical system	7	7	10	9
Surg	Multi-gas anesthesia monitor	8	9	8	14
Surg	Robotic surgical system	7	7	7	10
Surg	Steam sterilizer, medium	12	8	15	12
Surg	Surgical light, ceiling mounted	10	12	10	21
Surg	Surgical table	15	12	15	18
Surg	Waste management system	10	8	10	7
DI	Bone density scanner	7	5	10	15
DI	Contrast injector, angiographic	10	10	10	20
DI	CT scanner (33-128 slices)	5	6	8	25
DI	Diagnostic US, cardiac	5	5	5	13
DI	Diagnostic US, general purpose	5	5	5	13
DI	Diagnostic US, point of care	5	5	4	14
DI	Digital mammography unit	5	6	7	14
DI	Mobile X-ray	7	7	15	15
DI	MRI scanner	5	9	10	16
DI	Nuc Med camera	5	8	10	21
DI	PACS work station	5	5	7	12
DI	Radiology flat panel detector	5	6	10	22
DI	Ultrasonic bladder scanner	5	5	4	12
Lab	Blood gas/pH analyzer	5	7	7	8
Lab	Chemistry analyzer	5	7	7	12
Lab	Coagulation analyzer	5	7	6	14
Lab	Hematology analyzer	7	7	7	13
Lab	Refrigerated centrifuge	5	6	10	25
Lab	Table-top centrifuge	7	6	10	16

	AHA EUL	VHA LE	ECRI ExUL	ELE
average	**6.5**	**7.5**	**8.5**	**15.5**
standard deviation	2.1	1.6	2.2	4.0

CONTENTS

- INTRODUCTION
  - Why study equipment disposal pattern and lifespan?
  - Prior studies/recommendations
  - Summary of our prior study results
- METHODOLOGY
  - Data source & analysis
- RESULTS
  - Disposal pattern
  - Lifespan estimation
- DISCUSSION
- CONCLUSIONS

DISCUSSION

- Study Limitations
  - Like our prior study, data integrity was a challenge, but the LLN helped us to reduce the risks of misinterpretations, except when the inventory was very small (<30 units)
  - Bundling multiple brands and models may have added some confusion. Only future studies with single brand/model can solve this challenge
  - Unfortunately, failure causes were NOT identified in the older workorders, so it is not possible to differentiate "natural" wear out from "abnormal" wear out, i.e., accessories, batteries, use (accidents, abuse, environmental issues, etc.)
  - Often equipment is replaced when a single catastrophic failure occurred and the repair cost is considered NOT worthwhile (e.g., >30-50% of fair-market value) so no clear end-of-life can be detected.
- Some may question possible risks to patient safety and care effectiveness when using equipment well beyond OEM's EOL/EOS recommendations. However, the fact that HDOs continue to deploy older equipment without suffering accreditation challenges, patient dissatisfaction and lawsuits suggests that these concerns are not valid.
- One must recognize, however, that many of the older equipment may be primarily used as back-ups during high census and/or emergencies may attenuate the risks concerns.
- Some old equipment are used only by a few users ("physician preference" items)

DISCUSSION (cont.)

- ELEs were calculated to serve a reference and compare with AHA's EUL, VHA's LE and ECRI's ExUL, not as a recommendation for replacement
- Our results show clearly that most of the AHA's EULs, VHA's LEs and ECRI's ExULs, except for equipment groups notorious "cheaply made" (lack of robustness/reliability), are **too short**.
- As AHA itself admitted in its book,
    - "The estimated service life for each asset as presented in this booklet is to be used primarily as a guide. An organization may consider assigning a longer or shorter life depending on usage, types of facility, and extenuating circumstances affecting the service life of the asset." [my emphasis in blue]
    - "The method for determining the depreciable cost is largely dependent on the productive period of the asset. Numerous factors influence this determination… Another contributing factor has to do with technological innovation, which can render an asset obsolete before the end of its estimated useful life." [my emphasis in blue]

CONCLUSIONS

- While no equipment can last forever, most equipment can be used safely and effectively well beyond the AHA's EULs, VHA's LEs and ECRI's ExULs or OEM-recommended EOL/EOS.
- Thus, both maintenance and replacement planning should NOT be based on those recommendations.
- Instead, age should be used only as one of the several criteria along with safety, reliability, supportability and clinical impact.
- AHA's EULs are fine for asset depreciation its impact is mostly on the financial side (helps to seek more donations or lower taxes) and does not affect directly patient safety or care
- CAUTION: While analyses of large databases provide quick and solid statistical results, be careful in using them on your local assets. Your equipment utilization and robustness/reliability may be quite different (e.g., defib's used in ambulances and EDs). So use statistics from large databases as the starting point to look for equipment types with clear wear out patterns in your own inventory.

THANK YOU

- Questions & suggestions are most welcome!
- Contact information:

  - **Binseng Wang**
  - Email: Binseng.wang@sodexo.com

  - **Torgeir Rui**
  - Email: Torgeir.rui@sodexo.com