MEDICAL IMAGING MARKETS
(SAMPLE COPY, NOT FOR RESALE)

Trends, Industry Participants, Product Overviews and Market Drivers
TABLE OF CONTENTS

1. Overview 17
   1.1 Statement of This Report 17
   1.2 Scope of This Report 17
   1.3 Methodology 19
   1.4 Executive Summary 20
2. Medical Imaging Technologies: An Overview 22
   2.1 X-Ray 22
     2.1.1 Types of X-Rays 22
       2.1.1.1 Applications of X-Ray (Radiography) 23
       2.1.1.2 Reduced Payments for Analog X-Ray in the U.S. from 2017 24
   2.2 Computed Radiography (CR) 25
   2.3 Digital Radiography (DR) 27
     2.3.1 Refinements in Digital Radiography Systems 28
     2.3.2 Digital Detectors 28
     2.3.3 Cassette-Based Solutions 29
     2.3.4 Benefits of Digital Radiography 30
   2.4 Fluoroscopy and C-Arms Systems 32
     2.4.1 C-Arm Machines with Cost Price $10,000 to $30,000 32
     2.4.2 C-Arm Machines with Cost Price $30,000 to $50,000 32
     2.4.3 C-Arm Machines with Cost Price $50,000 to $70,000 33
     2.4.4 C-Arm Machines with Cost Price $70,000 to $120,000 33
     2.4.5 Points to be Considered While Buying a C-Arm System 33
     2.4.5.1 Digital Detector vs. Image Intensifier 33
     2.4.5.2 II Size 34
     2.4.5.3 II Magnification Modes 34
     2.4.5.4 Generator Size 34
     2.4.5.5 Current Price Range 34
   2.5 Mammography 34
     2.5.1 Film/Screen Systems for Mammography 35
     2.5.2 Full Field Digital Mammography 35
     2.5.3 Clinical Applications of Mammography Systems 35
     2.5.4 Components of a Mammography System 35
     2.5.5 List Price of Select Mammography Systems 35
     2.5.6 Points to be Considered While Buying a Mammography System 35
     2.5.6.1 Detector Size 36
     2.5.6.2 Image Resolution 36
     2.5.6.3 Upgradability 36
   2.6 Bone Densitometry Scanners 36
   2.7 Computed Tomography (CT) 37
     2.7.1 Types of CT Scanners 37
     2.7.1.1 16 Slice CT Scanners 38
     2.7.1.2 32 to 40 Slice CT Scanners 38
     2.7.1.3 64 Slice CT Scanners 38
     2.7.1.4 Wide-Bore CT Scanners 39
     2.7.1.5 Greater Than 64 Slice CT Scanners 39
   2.8 MRI Scanners 40
     2.8.1 Types of MRI Scanners 40
     2.8.1.1 High-Field MRI Scanners 40
     2.8.1.2 Low-Field MRI Scanners 41
     2.8.1.2 Low-Field MRI Scanners 41
     2.8.1.3 Upright MRI Scanners 41
     2.8.2 MRI Machines that Cost $150,000 or Less 41
     2.8.3 MRI Machines That Cost $150,000 to $300,000 41
     2.8.4 MRI Machines That Cost $250,000 to $400,000 42
4.13.2 Global Market for Bone Densitometry by Geography
88
4.14 Global Market for Refurbished Diagnostic Imaging Equipment Market
89
4.14.1 Global Market for Refurbished Medical Imaging Equipment by Technology
90
5. Medical Imaging Market Data from Select Countries  92
5.1 U.S. Market for Diagnostic Imaging Equipment 92
5.1.1 Average Cost of Imaging Procedures in the U.S. Hospital Setting 93
5.1.2 Average Expenses per Procedure by Modality in the U.S. Free-Standing Imaging Centers 94
5.1.3 Number of CT Procedures in the U.S. 95
5.1.3.1 U.S. Distribution of CT Sites by Site Type 96
5.1.3.2 Distribution of CT Scanners in the U.S. by Slice Count 97
5.1.3.3 CT Procedure Mix in the U.S. 98
5.1.4 Mammography in the U.S. 100
5.1.5 MRI in the U.S. 101
5.1.5.1 MRI Procedure Mix in the U.S. 102
5.1.5.2 Distribution of Installed Base of MRI Systems by Bore Type, by Site Type in the U.S. 104
5.1.5.3 Distribution of Installed Base of MRI Systems by Magnet Field Strength in the U.S. 105
5.1.5.4 MRI Installed Base in the U.S. by Field Strength 107
5.1.6 Number of Clinical PET Scans, Sites and Units in the U.S. 108
5.1.6.1 Clinical PET Scan Trends in the U.S. 109
5.1.6.2 PET Clinical Patient Scan Mix in the U.S. 110
5.1.6.3 PET/CT and PET Oncology Study Mix in the U.S. 111
5.1.6.4 PET/CT Installed Base in the U.S. by Number of CT Slices 112
5.2 Medical Imaging in Canada 113
5.2.1 Computed Tomography (CT) 113
5.2.2 Magnetic Resonance Imaging 113
5.2.3 Single-Photon Emission Computed Tomography 113
5.2.4 Positron Emission Tomography/Computed Tomography (PET/CT) 114
5.2.5 Positron Emission Tomography/Magnetic Resonance Imaging (PET/MRI) 114
5.2.6 Single-Photon Emission Computed Tomography/Computed Tomography (SPECT/CT) 114
5.2.7 Picture Archiving Communication System (PACS) 114
5.2.8 Leading Medical Imaging Companies in Canadian Market 115
5.2.9 Growth Rate for Medical Imaging Equipment in Canada 116
5.2.10 Market Share for Major Imaging Devices in Canada 117
5.3 European Market for Medical Imaging in Select Countries 118
5.3.1 Installed Bases of Major Medical Imaging Modalities in Europe 119
5.3.2 Age Profile of CT Scanners in Major European Healthcare Markets 120
5.3.2.1 Age Profiles of CT Scanners in Select Region/Country 122
5.3.2.2 Upgraded and Replaced CT Units in Europe 123
5.3.2.3 Density of CT Units in Select Region/Country 124
5.3.3 Age Profile of MRI in Select Region/Country 125
5.3.3.1 Density of MRI Units in Select Region/Country 126
5.3.4 Profile of X-Ray Angiography Units in Major European Healthcare Markets 127
5.3.4.1 Age Profile of X-Ray Angiography in Select Region/Country 128
5.3.5 Age Profile of PET Scanners in E.U. 130
5.3.5.1 Age Profile of PET in Select Region/Country 131
5.3.5.2 Density of PET in Select Markets 132
5.4 Chinese Market for Medical Imaging Equipment 133
5.5 Indian X-Ray Market 134
5.5.1 Indian Digital Radiography Market (DR) 135
5.5.2 Indian Ultrasound Market 136
5.5.2.1 Indian Color Doppler Equipment Market 137
5.5.2.2 Indian Color Ultrasound Market 138
5.5.3 Indian CT Scanners Market 139
5.5.4 Indian MRI Market 140
5.5.5 Indian SPECT and PET Market 141
6. Company Profiles

6.1 Siemens Healthcare

6.1.1 Angiography Products

6.1.1.1 Artis One

6.1.1.2 Artis Q

6.1.1.3 Artis Zeego

6.1.1.4 Artis Pheno

6.1.1.5 Artis Zee

6.1.1.6 Artis QZen

6.1.1.7 MIYABI Angio-CT

6.1.2 Mobile C-Arms from Siemens

6.1.2.1 Cios Alpha

6.1.2.2 Cios Fusion

6.1.2.3 Cios Connect

6.1.2.4 Cios Select

6.1.2.5 Arcadis Orbie 3D

6.1.2.6 Siremobil Compact L

6.1.3 CT Scanners from Siemens

6.1.3.1 SOMATOM Force

6.1.3.2 SOMATOM Drive

6.1.3.3 SoMATOM Definition Flash

6.1.3.4 SOMATOM Definition Edge

6.1.3.5 SOMATOM Definition AS

6.1.3.6 SOMATOM Perspective

6.1.3.7 SOMATOM go.Up

6.1.3.8 SOMATOM go.Now

6.1.3.10 SOMATOM Scope

6.1.3.11 SOMATOM Emotion

6.1.3.12 SOMATOM Spirit

6.1.4 Remote Controlled Fluoroscopy Systems

6.1.4.1 Luminos dRF Max

6.1.4.2 Luminos Fusion

6.1.4.3 Luminos Select

6.1.5 Magnetic Resonance Imaging Systems from Siemens

6.1.5.1 MAGNETOM Aera

6.1.5.2 MAGNETOM Amira

6.1.5.3 MAGNETOM Sempra

6.1.5.4 MAGNETOM Espree eco

6.1.5.5 MAGNETOM Avanto eco

6.1.5.6 MAGNETOM Essenza

6.1.5.7 MAGNETOM Vida

6.1.5.8 MAGNETOM Skyra

6.1.5.9 MAGNETOM Prisma

6.1.5.10 MAGNETOM Verio

6.1.5.11 MAGNETOM Spectra

6.1.6 Mammography Systems from Siemens

6.1.6.1 Mammmomat Inspiration

6.1.6.2 Mammmomat Fusion

6.1.7 Molecular Imaging Systems from Siemens

6.1.7.1 Biograph mCT Flow PET/CT

6.1.7.2 Biograph mCT

6.1.7.3 Biograph Horizon

6.1.7.4 Symbia Intevo

6.1.7.5 Symbia Intevo Excel

6.1.7.6 Symbia T Series
6.1.8 Ultrasound Systems from Siemens 149
6.1.8.1 ACUSON SC2000 149
6.1.8.2 ACUSON X700 149
6.1.8.3 ACUSON X300 PE 150
6.1.8.4 ACUSON X150 150
6.1.8.5 ACUSON P300 150
6.1.8.6 ACUSON S2000i50 150
6.1.8.7 ACUSON S1000i50 150
6.1.8.8 ACUSON S3000i50 150
6.2 GE Healthcare 151
6.2.1 GE’s Bone Health Imaging Products 151
6.2.1.1 Lunar iDXA 151
6.2.1.2 Prodigy 151
6.2.1.3 Achilles 151
6.2.2 Computed Tomography from GE 151
6.2.2.1 Revolution EVO 151
6.2.2.2 Revolution CT 152
6.2.2.3 Optima CT660 152
6.2.2.4 Optima CT540 152
6.2.2.5 Optima CT660 FREEdom Edition 152
6.2.2.6 Optima CT 580 W 152
6.2.3 MRI from GE Healthcare 152
6.2.3.1 SIGNA Architect 152
6.2.3.2 SIGNA Pioneer 153
6.2.3.3 Discovery MR750w GEM 70 cm 153
6.2.3.4 Discovery MR750 60 cm 153
6.2.3.5 SIGNA PET/MR 60 cm 153
6.2.4 Mammography Equipment from GE Healthcare 153
6.2.4.1 Senographe Pristina 153
6.2.5 Nuclear Imaging Systems from GE Healthcare 153
6.2.5.1 Discovery MI 153
6.2.5.2 Discovery IQ 154
6.2.5.3 Discovery MI DR 154
6.2.5.4 Discovery NM CT 670 154
6.2.5.5 Optima NM CT 640 154
6.2.5.6 Infinia Hawkeye 4 154
6.2.6 Select Radiography Systems from GE Healthcare 154
6.2.6.1 Proteus XR/f 154
6.2.6.2 Discovery XR656 PLUS 154
6.2.6.3 Definium 5000 155
6.2.7 Select Fluoroscopy Systems from GE Healthcare 155
6.2.7.1 Precision 600FP 155
6.2.8 Select Ultrasound Systems from GE Healthcare 155
6.2.8.1 Voluson E10 155
6.2.8.2 LOGIQ E9 XDclear 2.0 155
6.2.8.3 LOGIQ F8 155
6.2.8.4 Vivid E95 155
6.3 Philips Healthcare 156
6.3.1 CT Devices from Philips 156
6.3.1.1 iQon Spectral CT 156
6.3.1.2 iCT Family 156
6.3.1.3 Ingenuity 156
6.3.1.4 Brilliance CT Big Bore 157
6.3.1.5 MX16 EVO 157
6.3.2 MRI from Philips Healthcare 157
6.3.2.1 Ingenia 1.5T 157
6.3.2.2 Ingenia 1.5T CX 158
6.3.2.3 Ingenia 1.5T S 158
6.3.2.4 Ingenia 3.0T 158
6.3.3 Diagnostic Radiography/Fluoroscopy from Philips 158
6.3.3.1 Juno DRF 158
6.3.3.2 EasyDiagnost Eleva DRF 158
6.3.4 Mammography Systems from Philips 159
6.3.4.1 MicroDose SI 159
6.3.4.2 IntelliSpace Breast 159
6.3.5 Digital Radiography Systems from Philips 159
6.3.5.1 DigitalDiagnost 159
6.3.5.2 MobileDiagnost 159
6.3.5.3 DuraDiagnost 159
6.3.6 Ultrasound Systems from Philips 159
6.3.6.1 EPIQ 7 159
6.3.6.2 EPIQ 5 160
6.3.6.3 Affinity 70 160
6.3.6.4 Affinity 50 160
6.3.6.5 CX 50 160
6.3.6.6 CX 50 xMatrix 160
6.3.6.7 ClearVue 850 160
6.3.6.8 Lumify 161
6.3.6.9 ClearVue 350 161
6.4 Toshiba Medical Systems Corporation 161
6.4.1 Computed Tomography (CT) from Toshiba 161
6.4.1.1 Aquilion ONE/Genesis Edition 161
6.4.1.2 Aquilion ONE VISION Edition 161
6.4.1.3 Aquilion ONE 161
6.4.1.4 Aquilon PRIME 162
6.4.1.5 Aquilion CXL Series 162
6.4.1.6 Aquilion RXL Edition 162
6.4.1.7 Aquilion Lightning 162
6.4.1.8 Aquilion LB 162
6.4.1.9 Alexion Advance Edition 163
6.4.1.10 Alexion 163
6.4.1.11 Alexion Access Edition 163
6.4.2 MRI from Toshiba 163
6.4.2.1 Vantage Titan 3T 163
6.4.2.2 Vantage Titan 163
6.4.2.3 Vantage Elan 163
6.4.3 Ultrasound from Toshiba 164
6.4.3.1 Aplio i-Series 164
6.4.3.2 Aplio 500 164
6.4.3.3 Aplio 400 164
6.4.3.4 Aplio 300 164
6.4.3.5 Xario 164
6.4.4 Fluoroscopy Systems from Toshiba 164
6.4.4.1 Ultimax-iFPD Version 164
6.4.4.2 Ultimax-i I.I. Version 165
6.4.4.3 ZEXIRA I.I. Version 165
6.4.4.4 Kalare 165
6.4.4.5 WINSCOPE Plessart EX8 165
6.4.4.6 WINSCOPE Plessart VIVO 165
6.4.5 Radiography Systems from Toshiba 165
6.4.5.1 RADREX-I FPD System 165
6.4.5.2 RADREX 165
6.4.6 Mammography from Toshiba 166
6.4.6.1 MGU-1000A 166
6.4.7 Mobile C-Arm from Toshiba 166
6.4.7.1 Surginix (SXT-2000A) 166
6.4.7.2 Clearscope 1000 166
6.4.8 Nuclear Imaging from Toshiba 166
6.4.8.1 Celesteion 166
6.5 Fujifilm Corporation 167
6.5.1 Computed Radiography Systems from Fujifilm 167
6.5.1.1 FCR Prima II 167
6.5.1.2 FCR Prima T2 167
6.5.1.3 FCR Prima T 167
6.5.1.4 FCR Capsula X 167
6.5.1.5 FCR Capsula XLI1 167
6.5.1.6 FCR XG5000 Plus 168
6.5.1.7 FCR Profect CS Plus 168
6.5.2 Digital Radiography from Fujifilm 168
6.5.2.1 FDR AcSelerate 168
6.5.2.2 FDR D-EVO Suite 168
6.5.2.3 FDR Visionary Suite 168
6.5.2.4 FDR Smart f 168
6.5.3 Digital Mammography System from Fujifilm 169
6.5.3.1 AMULET Innovality 169
6.5.3.2 AMULET f/s 169
6.5.3.3 AMULET 169
6.5.4 Ultrasound Systems from Fujifilm 169
6.5.4.1 FC1 169
6.5.4.2 SonoSite SII 169
6.5.4.3 SonoSite Edge II 170
6.5.4.4 SonoSite iViz 170
6.5.4.5 SonoSite X-Porte 170
6.5.4.6 SonoSite NanoMaxx 170
6.5.4.7 SonoSite M-Turbo 170
6.5.4.8 Vevo MD 170
6.6 Carestream Health Inc. 171
6.6.1 DR Systems from Carestream 171
6.6.1.1 DRX-Evolution Plus 171
6.6.1.2 DRX-I System 171
6.6.1.3 DRX-Ascend 171
6.6.1.4 DRX – Mobile Retrofit 171
6.6.1.5 DRX-Revolution 172
6.6.1.6 DRX-Transportable 172
6.6.2 CR Systems from Carestream 172
6.6.2.1 DirectView CR System 172
6.6.2.2 Vita Flex CR System 172
6.6.2.3 Vita CR System 172
6.6.3 Cone Beam CT Solutions from Carestream 173
6.6.3.1 Carestream OnSight 3D Extremity System 173
6.6.3.2 CS 9300 System 173
6.6.3.3 CS 8100 3D System 173
6.6.4 Fluoroscopy from Carestream 173
6.6.4.1 DRX-Excel 173
6.6.4.2 DRX-Excel Plus 173
6.6.5 Analog System from Carestream 174
6.6.5.1 DRX-Ascend System 174
6.6.5.2 Motion Mobile X-Ray System 174
6.6.6  Ultrasound Systems from Carestream 174
6.6.6.1  Touch Prime 174
6.6.6.2  Touch Prime XE 174
6.6.7  Digital Mammography Systems from Carestream 175
6.6.7.1  CARESTREAM DRX-1 System 175
6.6.7.2  CARESTREAM DRX Mobile Retrofit Kits 175
6.6.7.3  CARESTREAM DRX-Revolution Mobile X-Ray System 175
6.6.7.4  CARESTREAM DRX-Evolution Plus 175
6.6.7.5  CARESTREAM DRX-Ascend System 176
6.7  Hitachi Medical Systems America Inc. 176
6.7.1  MRI Systems from Hitachi 176
6.7.1.1  Oasis 1.2T 176
6.7.1.2  Echelon Oval 1.5T 176
6.7.1.3  Echelon 1.5T 176
6.7.2  CT Systems from Hitachi 177
6.7.2.1  SCENARIA 128-Slice 177
6.7.2.2  SUPRIA 16-Slice 177
6.7.3  Ultrasound Systems from Hitachi 177
6.7.3.1  ARIETTA 70 177
6.7.3.2  ProSound Alpha 7 177
6.7.3.3  Noblus 177
6.7.3.4  Profound F37 178
6.7.3.5  SOFIA 178
6.7.3.6  Profound F75 178
6.7.4  X-Ray Systems 178
6.7.4.1  DX-D 100 178
6.7.4.2  DX-D 300 179
6.7.4.3  DR 400 179
6.7.4.4  DX-D 600 179
6.8  Konica Minolta Medical Imaging U.S.A. Inc. 180
6.8.1  Konica’s Digital Radiography Products 180
6.8.1.1  AeroDR HD Detector 180
6.8.1.2  KDR AU System Advanced U-Arm 180
6.8.1.3  AeroRemote 180
6.8.1.4  AeroDR LT 180
6.8.1.5  AeroDR XE 180
6.8.1.6  AeroDR Flat Panel Detector 181
6.8.2  Ultrasound Systems from Konica 181
6.8.2.1  J5 Ultrasound 181
6.8.2.2  Sonimage HS 1 181
6.8.2.3  Sonimage P3 181
6.8.3  Computed Radiography from Konica 181
6.8.3.1  Xpress CR 181
6.8.3.2  Sigma II CS-7S CR 181
6.8.3.3  NanoCR W/CS-7 181
6.8.3.4  ImagePilot 182
6.8.3.5  ImagePilot Sigma 182
6.8.4  Konica’s Digital Mammography 182
6.8.4.1  Xpress CR – Contact Mammography 182
6.8.4.2  REGIUS 110 HQ 182
6.9  Shimadzu Corporation 182
6.9.1  Angiography Systems from Shimadzu 182
6.9.1.1  Trinias F12/C12 Mix Package 182
6.9.1.2  BRANSIST alexa F12/C12 183
6.9.2  Fluoroscopy from Shimadzu 183
6.9.2.1  Sonialvision G4 183
APPENDIX

Appendix 1: Basic Principles of CT Scanning 188
Appendix 1.1: Field of Use 190
Appendix 1.2: Technical Considerations 190
Appendix 1.3: Total Scan Time and Scan Length 191
Appendix 1.3.1: Clinical Requirements 191
Appendix 1.3.2: Gantry Rotation Time 191
Appendix 1.3.3: Detector Array Length 191
Appendix 1.3.4: X-Ray Tube 194
Appendix 1.3.5: Image Quality 194
Appendix 1.3.6: Spatial Resolution 195
Appendix 1.3.7: Contrast Resolution 197
Appendix 1.3.8: Temporal Resolution 197
Appendix 1.3.9: Image Artifacts 199
Appendix 1.3.10: Ionizing Radiation and Patient Dose 200
Appendix 1.3.11: Over-Beaming 201
Appendix 1.3.12: Over-Ranging in Helical Scanning 202
Appendix 1.3.13: Automatic Tube Current Control in CT 203
Appendix 1.3.14: Cardiac Scanning 203
Appendix 1.4: Installation 204
Appendix 1.4.1: Scanner Location 204
Appendix 1.4.2: Room Requirements 204
Appendix 1.4.3: Ancillary Equipment 205
Appendix 1.4.4: Patient Workflow 205
Figure 5.39: Indian Ultrasound Market by Volume and Value, 2015 136
Figure 5.40: Indian Color Doppler Equipment Market, 2015 137
Figure 5.41: Indian Color Ultrasound Equipment Market, 2016138
Figure 5.42: Indian CT Scanners Market, 2015 139
Figure 5.43: Indian Diagnostic MRI Market, 2015 140
Figure 5.44: Indian SPECT & PET Market, 2016 141
Figure A. 1.1: Schematic Diagram of CT Scanner “End View” 188
Figure A. 1.2: Schematic Diagram of CT Scanner “Side View” in Helical Acquisition Mode 188
Figure A. 1.3: Multi-slice CT Scanner X-Ray Beam and Detectors Approximately to Scale 189
Figure A. 1.4: Multi-slice CT Scanner X-Ray Beam and Detectors, Schematic 189
Figure A. 1.5: Technical Advances in CT Scanner Technology 190
Figure A. 1.6: Effect of Detector Array on Number of Rotations and Scan Time 192
Figure A. 1.7: Example of 16 Slice Detector with Reduced Coverage for Fine Slices 192
Figure A. 1.8: Examples of Fixed and Variable Z-Axis Detector Arrays 193
Figure A. 1.9: CT Perfusion with “Jog” or “Shuttle” Scan 194
Figure A. 1.10: Test Objects with Line Pairs of Varying Frequencies for Assessment of Scan Plane Spatial Resolution 195
Figure A. 1.11: Diagram of Methods for Improving Sampling Density (a) Quarter Detector Shift, (b) Flying Focal Spot 196
Figure A. 1.12: Reduction of Effective Detector Size with Attenuating Grid 196
Figure A. 1.13: Test Object for Contrast Resolution Measurements 197
Figure A. 1.14: Principle of Multi-Segment Reconstruction in Retrospectively Gated CCTA 198
Figure A. 1.15: Schematic Diagram of a Dual Source CT Scanner 198
Figure A. 1.16: CT Scan Through Shoulders, Demonstrating Photon Starvation Artifacts 199
Figure A. 1.18: PMMA Body Phantom used for Measurement of CT Doses 200
Figure A. 1.19: Illustration of CTDIvol Representing Average Dose at Central Slice Position of 100 mm Irradiation Length 201
Figure A. 1.20: Reduced Influence of Over-Beaming for Larger Z-Axis Beam Collimations 201
Figure A. 1.21: Dynamic Collimation to Reduce Dose at the Extremities of a Scan 202
Figure A. 1.22: Automatic Tube Current Control in CT 203
Figure A. 1.23: EEG-Gated Tube Current Modulation 203
Figure A. 1.24: The Stages of a CT Scan 206
Figure A. 1.25: Examples of Allocations of Specific Roles to Assist Patient Workflow 206
Figure A. 1.26: Information and Image Flow 207

INDEX OF TABLES

Table 2.1: Important Features of Different Imaging Modalities 22
Table 2.2: Percent Applications of X-Rays by Indication 23
Table 2.3: Medicare Reimbursement Cuts to X-Ray by Technology 24
Table 2.4: Features of Some of the Largest Selling CR Systems 26
Table 2.5: DR Systems in the Market 26
Table 2.6: Detector Types in Selected DR Systems 28
Table 2.7: Features of Cassette-Based DR Solutions from Different Vendors 29
Table 2.8: Select DR Systems 30
Table 2.9: 16 Slice CT Scanners 38
Table 2.10: 32 to 40 Slice CT Scanners 38
Table 2.11: 64 Slice CT Scanners 39
Table 2.12: Wide Bore CT Scanners 39
Table 2.13: Greater Than 64 Slice CT Scanners 40
Table 2.14: Examples of SPECT/CT Systems 47
Table 2.15: Select PET/CT Systems 49
Table 2.16: Select PACS Systems 49
Table 4.1: Global Medical Imaging Equipment Market by Technologies, 2016-2022 58
Table 4.2: Medical Imaging Equipment Market by Geography, 2016-2022 59
<table>
<thead>
<tr>
<th>Table 4.3: Top Ten Companies based on Diagnostic Imaging Market Share (%), 2016 and 2022</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 4.4: Global Market for X-Ray Systems by Technology, 2016-2022</td>
</tr>
<tr>
<td>Table 4.5: Global Market for Ultrasound by Technology, 2016-2022</td>
</tr>
<tr>
<td>Table 4.6: Global Market for MRI by Technology, 2016-2022</td>
</tr>
<tr>
<td>Table 4.7: Global CT Scanners Market by Technology, 2016-2022</td>
</tr>
<tr>
<td>Table 4.8: Global CT Scanners Market by Geography, 2016-2022</td>
</tr>
<tr>
<td>Table 4.9: Global Market for Nuclear Imaging Equipment (SPECT &amp; PET), 2016-2022</td>
</tr>
<tr>
<td>Table 4.10: Global Market for Breast Imaging Equipment, 2016-2022</td>
</tr>
<tr>
<td>Table 4.11: Global Market for Fluoroscopy and Mobile C-Arms, 2016-2022</td>
</tr>
<tr>
<td>Table 4.12: Global Market for Medical Imaging Software, 2016-2022</td>
</tr>
<tr>
<td>Table 4.13: Global Market for PACS by Imaging Modality, 2016-2022</td>
</tr>
<tr>
<td>Table 4.14: Global Market for Bone Densitometers by Technology, 2016-2022</td>
</tr>
<tr>
<td>Table 4.15: Global Market for Bone Densitometers by Geography, 2016-2022</td>
</tr>
<tr>
<td>Table 4.16: Global Market for Refurbished Diagnostic Imaging Equipment Market by Geography, 2016-2022</td>
</tr>
<tr>
<td>Table 4.17: Global Market for Refurbished Medical Imaging Equipment by Technology, 2016-2022</td>
</tr>
<tr>
<td>Table 5.1: U.S. Market for Medical Imaging by Technology, 2016-2022</td>
</tr>
<tr>
<td>Table 5.2: Average Expenses per Procedure by Modality in the U.S. Hospital Setting</td>
</tr>
<tr>
<td>Table 5.3: Average Expenses per Procedure by Modality in the U.S. Free-Standing Imaging Centers</td>
</tr>
<tr>
<td>Table 5.4: CT Procedure Volumes in the U.S. Hospital and Non-Hospital Sites, 2005-2015</td>
</tr>
<tr>
<td>Table 5.5: Distribution of CT Sites and Procedures by Site Type, 2015</td>
</tr>
<tr>
<td>Table 5.6: Distribution of CT Scanners in the U.S. by Number of Slices as of 2015</td>
</tr>
<tr>
<td>Table 5.7: Distribution of CT Procedures in the U.S. and Sites, by Procedure Category, 2015</td>
</tr>
<tr>
<td>Table 5.8: Type of Mammography Unit Installed in the U.S. as of 2015</td>
</tr>
<tr>
<td>Table 5.9: Total MRI Procedure Volume in the U.S., 2005-2015</td>
</tr>
<tr>
<td>Table 5.10: MRI Procedure Mix in the U.S., 2015</td>
</tr>
<tr>
<td>Table 5.11: Distribution of Installed Base of MRI Systems by Bore Type, by Site Type, 2015</td>
</tr>
<tr>
<td>Table 5.12: Distribution of Installed Base of MRI Systems by Magnet Field Strength in the U.S., 2015</td>
</tr>
<tr>
<td>Table 5.13: MRI Installed Base in the U.S. by Field Strength as of 2015</td>
</tr>
<tr>
<td>Table 5.14: Distribution of PET Imaging Sites and PET Scans by Site Type in the U.S., 2015</td>
</tr>
<tr>
<td>Table 5.15: Estimated Clinical PET Scans by Site Type, 2005-2015</td>
</tr>
<tr>
<td>Table 5.16: Clinical Application Mix for PET/CT and PET Scans in the U.S., 2015</td>
</tr>
<tr>
<td>Table 5.17: Distribution of PET Oncology Scans by Cancer Type in the U.S., 2015</td>
</tr>
<tr>
<td>Table 5.18: Percent Distribution of PET/CT Installed Base by Number of CT slices, 2015</td>
</tr>
<tr>
<td>Table 5.19: Canadian Medical Imaging Market Share by Company, 2016</td>
</tr>
<tr>
<td>Table 5.20: Canadian Medical Imaging Growth Rate by Segment, 2016</td>
</tr>
<tr>
<td>Table 5.21: Canadian Market Share for Major Imaging Equipment, 2016</td>
</tr>
<tr>
<td>Table 5.22: European Market for Medical Imaging in Select Countries, 2016-2022</td>
</tr>
<tr>
<td>Table 5.23: Installed Bases of Major Medical Imaging Modalities in Europe</td>
</tr>
<tr>
<td>Table 5.24: Age Profile of CT Scanners in Major European Healthcare Markets as of 2015</td>
</tr>
<tr>
<td>Table 5.25: Age Profiles of CT Scanners in Select Region/Country, 2015</td>
</tr>
<tr>
<td>Table 5.26: Upgraded and Replaced CT Units in Europe as of 2015</td>
</tr>
<tr>
<td>Table 5.27: Density of CT Units in Select Region/Country as of 2015</td>
</tr>
<tr>
<td>Table 5.28: Age Profile of MRI in Europe as of 2015</td>
</tr>
<tr>
<td>Table 5.29: Density of MRI Units in Select Region/Country as of 2015</td>
</tr>
<tr>
<td>Table 5.30: Age Profile of X-Ray Angiography Units in Major European Healthcare Markets as of 2015</td>
</tr>
<tr>
<td>Table 5.31: Age Profile of X-Ray Angiography in Select Region/Country as of 2015</td>
</tr>
<tr>
<td>Table 5.32: Density of X-Ray Angiography Units in Select Region/Country as of 2015</td>
</tr>
<tr>
<td>Table 5.33: Age Profile of PET Modalities in E.U. as of 2015</td>
</tr>
<tr>
<td>Table 5.34: Age Profile of PET in Select Region/Country as of 2015</td>
</tr>
<tr>
<td>Table 5.35: Density of PET Units by Select Region/Country as of 2015</td>
</tr>
<tr>
<td>Table 5.36: Chinese Market for Medical Imaging, 2016-2022</td>
</tr>
<tr>
<td>Table 5.37: Indian X-Ray Market, 2016</td>
</tr>
<tr>
<td>Table 5.38: Indian Digital Radiography (DR) Market, 2016</td>
</tr>
<tr>
<td>Table 5.39: Indian Ultrasound Market by Volume and Value, 2015</td>
</tr>
<tr>
<td>Table 5.40: Indian Color Doppler Equipment Market, 2015</td>
</tr>
</tbody>
</table>
Table 5.41: Leading Vendors in Indian Ultrasound Market, 2015
Table 5.42: Indian Color Ultrasound Equipment Market, 2016
Table 5.43: Indian CT Scanners Market, 2015
Table 5.44: Indian Diagnostic MRI Market, 2015
Table 5.45: Indian SPECT & PET Market, 2016
Table A.2.1: 1.5 T and 3.0 T Models Evaluated by PASA
Table A.2.2: Key Technical Specifications for 1.5 T Equipment
Table A.2.3: Key Technical Specifications for 3 T Equipment
Table A.3.1: Ionizing and Non-Ionizing Sources of Radiation
Table A.3.2: Common Sources of Radiation
Table A.3.3: Radiation Dose for Various Imaging Procedures Compared to Natural Radiation
Table A.3.4: Proper Protection from Ionizing Radiation
Table A.3.5: Radiation-Induced Malformations from Fetal Exposure
Table A.3.6: Estimated Radiation Dose Received by Fetus during Imaging Procedures
1. **Overview**

1.1 **Statement of This Report**

The purpose of this TriMark Publications report is to describe the specific market segment of the diagnostics market sector called medical imaging. Medical imaging can be categorized into nine main modalities: X-ray, ultrasound, computed tomography (CT), positron emission tomography (PET), single photon emission computed tomography (SPECT), magnetic resonance imaging (MRI), nuclear medicine (NM), mammography, and fluoroscopy. Globally, the X-ray is the most frequently used imaging procedure with more than [number] X-ray exams per year. MRIs are second with [number] examinations per year. PET, SPECT, CT and nuclear medicine rank third with [number] examinations per year. Picture archiving and communication systems (PACS) and contrast agents are the sub-segments in medical imaging market that have gained significant growth in recent years. As a result of these medical imaging advancements, the multi-slice systems are generating large volumes of data, and this creates demand for data storage, three-dimensional (3-D) visualization and analysis. As such, the global medical imaging industry is primed to experience significant growth through the next decade. This report surveys almost all of the companies known to be marketing, manufacturing or developing medical imaging equipment and supplies in the world. Each company is discussed in extensive depth with a section on its history, product line, business and marketing analysis, and a subjective commentary of the company’s market position. Detailed tables and charts with sales forecasts and market data are also included.

The huge revenue earning potential of the medical imaging industry is primarily due to the general cost of most imaging equipment and its functional benefits. The value of the global imaging industry has grown from $[number] billion in [year] to $[number] billion in [year]. The U.S. and Europe are the most mature markets for the medical imaging products, and they show a compounded annual growth rate (CAGR) hovering around [percentage]% growth. Product innovations will play a key role in further progression of the medical imaging in these two mature markets. For the existing medical imaging products, the vendors are now focusing on the regional markets such as China and India, which have shown to experience a CAGR of [percentage]% to [percentage]% growth. China’s healthcare sector has witnessed a robust growth assisted by growing demand and government support. The medical devices market in India is anticipated to register an annual growth rate in the high double digits in the coming years and the medical imaging market will form a major part of it. Public hospitals in the Eastern European region are also seeking assistance from private finance companies to invest in the latest medical imaging modalities. The overall analysis of the growth pattern indicates that the private imaging centers are gaining momentum and most public sector healthcare services are focusing on outsourcing imaging diagnostics.

1.2 **Scope of This Report**

The main objectives of this analysis are:

- Estimate the current and future U.S. and global markets for medical imaging modalities.
- Assess market opportunities and the potential market for medical imaging products.
- Discuss the shift in trends towards portable devices in medical imaging.
- Analyze the need for medical imaging for the different disease indications.
- Examine the current utilization and future demand for radiopharmaceuticals used in nuclear imaging procedures.
- Review the impact of healthcare reforms on medical imaging procedures and the reimbursement rates available in the U.S. for the different imaging procedures.
- Identify the key players in medical imaging industry and their contribution to the continuing innovations in the development of new modalities.

Key questions answered in this study are:

- What disease conditions offer the greatest potential for medical imaging?
- What market drivers are responsible for the growth of medical imaging products?
- Which healthcare segments contribute more to the growth of medical imaging industry?
- What regulatory and technical challenges is the medical imaging industry confronting?
• How far has the industry progressed in developing portable imaging equipment?
• What is the reimbursement rate for the different imaging procedures in the U.S.?
• What impacts have U.S. healthcare reforms made on the growth of medical imaging industry?

This report contains:

• A brief introduction to the various medical imaging modalities, the market leading brands in each modality and the medical applications for each.
• Global, U.S., European, Chinese and Indian markets for medical imaging modalities.
• Estimated market for medical imaging products at the global and the U.S. level.
• The current status of the isotope supply to the global radiology market.
• One section of the appendix gives a detailed account of the global and regional markets for refurbished imaging modalities such as CT, MRI and ultrasound.

For more information on the U.S. and global markets for medical imaging equipment, please visit http://www.trimarkpublications.com to find this study’s companion report called European Medical Imaging Markets. Other TriMark reports cover the specific sectors within the medical imaging market include: Mammography World Markets, Nuclear Cardiology Markets, Picture Archiving and Communications Systems (PACS), Positron Emission Tomography (PET) Markets and Ultrasound Markets.

1.3 Methodology

The author of this report is a Ph.D. in biochemistry from the University of Minnesota with many decades of experience in science writing and as a medical industry analyst. He has been a senior director of several large regional and national healthcare laboratories. The editor of this report is a retired college professor with three decades of experience in teaching biochemistry, biotechnology, pharmacology, environmental biology and horticulture. Additionally, important data sources include the American Hospital Association (AHA), American College of Radiology (ACR), World Health Organization (WHO), National Cancer Institute, American Cancer Society (ACS) and Medical Imaging & Technology Alliance (MITA). Where possible and practicable, the most recent data available have been used.

Some of the statistical information was taken from Biotechnology Associates’ databases and from TriMark’s private data stores. The information in this study was obtained from sources that TriMark believes to be reliable, but TriMark does not guarantee the accuracy, adequacy or completeness of any information or omission or for the results obtained by the use of such information. Key information from the business literature was used as a basis to conduct dialogue with and obtain expert opinion from market professionals regarding commercial potential and market sizes.

Primary Sources

TriMark collects information from hundreds of database tables and many comprehensive multi-client research projects and Sector Snapshots published annually. TriMark extracts relevant data and analytics from its research in the past three years as part of this data collection. TriMark also extracts qualified data feeds from e-questionnaire responses and primary research responses for this compilation.

Secondary Sources

TriMark uses research publications, journals, magazines, newspapers, newsletters, industry reports, investment research reports, trade and industry association reports, government affiliated trade releases, and other published information as part of its secondary research materials. The information is then analyzed and translated by the Industry Research Group into a TriMark study. The Editorial Group reviews the complete package with product and market forecasts, critical industry trends, threats and opportunities, competitive strategies and market share
determinations. The report conclusions are verified through intensive interviewing of the top-ranking companies in the industry.

**TriMark Publications Report, Research and Data Acquisition Structure**

The general sequence of research and analysis activity prior to the publication of every report in TriMark Publications includes the following items:

- Completing an extensive secondary research effort on an important market sector, including gathering all relevant information from corporate reporting, publicly-available data and proprietary databases.
- Formulating a study outline with the assigned writer, including important items, as follows:
  - Market and product segment grouping, including evaluating their relative significance.
  - Evaluation of key competitors, including their relative positions in the business and other relevant facts to prioritize diligence levels and assist in designing a primary research strategy.
  - End-user research to evaluate analytical significance in market estimation.
  - Supply chain research and analysis to identify any factors affecting the market.
  - New technology platforms and cutting-edge applications.
- Identifying the key technology and market trends that drive or affect these markets.
- Assessing the regional significance for each product and market segment for proper emphasis of further regional/national primary and secondary research.
- Completing a confirmatory primary research assessment of the report’s findings with the assistance of expert panel partners.

### 1.4 Executive Summary

The medical imaging industry is on the brink of a major new phase of growth. The growth in the market will be propelled by the availability of new technology coming from the digital information segment and by the aging population. Equipment vendors are being forced to design smaller and lower cost modalities. Recent innovations in the continued integration of technologies are showing much promise. Advances in PET/CT systems enable images to be seen that have never been seen before simultaneously. Another area showing promise is functional MRI (fMRI), which can enable advances in diagnostics for diseases such as Alzheimer’s and other diseases that are becoming more prevalent with an aging population. The global market for medical imaging is worth about $39.7 billion in 2016, and is expected to grow to $54.9 billion by 2022. Currently, Asia/Pacific is the largest market that is worth about $20.4 billion and it is followed by North America and Europe with shares of $16.5 billion and $9.9 billion respectively.

CT continues to be a much sought after equipment in both inpatient and outpatient care. In mature markets, such as the U.S. and Europe, the purchase of new equipment is driven by an additional need for capacity. One week’s backlog justifies the investment in another unit for CT because the facilities do not want their clients to go to their competitors. Another factor is obsolescence. Some clinicians still use a one-slice CT and manage to perform well. Some think that they need to have a 16-slice CT to do a good job. This perception of obsolescence varies among the institutions. The global CT market is controlled mainly by five major players, namely GE Healthcare, Hitachi Medical Systems, Philips Medical Systems, Siemens Medical Solutions, and Toshiba Medical Systems. The global CT scanners market was valued at $4.8 billion in 2016 with a potential to reach $6.2 billion in 2022.

MRI is the ideal system for imaging soft tissues. Yet, for several years, the small bore had been a disadvantage for both obese and claustrophobic patients. In 2012, many MRI vendors launched systems with a wide bore. Hitachi received FDA approval for its Echelon Oval 1.5T wide-bore system in 2012 and it is the only system in the industry to provide a 74 cm bore. Nearly two-thirds of the customers are likely to opt for wide bore units. Another boon for the MRI market is the advent of MRI-compatible pacemakers and other devices. Technological advances such as ultra-high-field MRI, innovative software applications, and novel detection of multiple sclerosis and breast cancer also contribute to boost the MRI market.

In the U.S., the MRI utilization rate has increased and yet there is revenue drop because of reimbursement cuts. Much of the procedure growth has been due to growth in lower and upper extremity procedure growth. According to
AllTech Medical Systems, there are approximately fixed MRI systems in operation in the U.S. and scanning is performed in more than hospitals, hospital-owned outpatient locations and nearly freestanding imaging centers. Over MRI scans are performed in the U.S. each year, with increased applications in chest, vascular, breast and cardiac imaging procedures. The global market for MRI systems was valued at $ and it has the potential to reach $ in.

PET scanners are used to assess cancers and neurological and cardiovascular disorders. These scanning systems are capable of revealing changes in metabolism and thus different types of cancers can be detected using PET before they can be detected by other imaging techniques. PET can scan the entire body and thus it can be used to show whether cancer is spreading to other parts of the body. PET is a more advanced and accurate technology for cardiac perfusion imaging and it has been shown to provide a % reduction in invasive coronary arteriography and coronary artery bypass grafting, resulting in % cost savings and superior clinical outcomes. New procedures combine PET with computed X-ray tomography (CT) scans to give co-registration of the two images (PET-CT) result in better diagnosis than with a traditional gamma camera alone. It is a very powerful and significant tool which provides unique information on a wide variety of diseases from dementia to cardiovascular disease and oncology.

Single Photon Emission Computed Tomography (SPECT) is a tomographic technique. Radioactive gamma rays are emitted from the human body by the injected radiopharmaceuticals. A gamma ray detection camera captures two-dimensional images from more than one angle. The tomographic reconstruction algorithm is applied to the two-dimensional images to form a three-dimensional image. The final image is manipulated to view images of the human body along a desired axis. The majority of SPECT usage in the U.S. is for cardiac imaging. The global market for nuclear imaging, which encompasses PET, PET/CT, and SPECT instruments, was worth $ in and it is likely to have a value of $ in.

The ultrasound market has been a stable presence that continues to expand. While 2D ultrasounds have the largest market share due to its wide use in brain tumor and fetal screening and its low cost, 3D and 4D imaging has grown as new applications are developed. Traditionally, ultrasound is primarily used to capture images for gynecology, vascular, and cardiac care. However, its application has broadened into orthopedics, critical care, sports medicine, rheumatology, pain clinics and numerous other medical specialties and has contributed to market expansion. For instance, high-intensity focused ultrasound (HIFU) is being used for treating prostate cancer. The other therapeutic use of ultrasound is for treating kidney stones and gallstones using extracorporeal shockwave lithotripsy. Point of care ultrasound, which saw double-digit growth in , is another major driver. The global market for ultrasound systems was worth about $ and it has the potential to reach $ by.

Mammography has come a long way: from the first breast-specific X-ray unit (Sénographe), to the modern second-generation digital mammography systems such as the Mammmomat Inspiration. The modern digital mammography systems can detect lesions as small as 0.2 cm in size allowing early treatment and improving overall breast cancer survival statistics substantially. Growth is being driven by the incidence of breast cancer as the population ages and the increase in early detection throughout the world. Technological advances contributing to growth include the greater use of 3D systems and advanced systems that can overcome issues of imaging dense breast tissue. The global market for breast imaging systems was valued at $ and it will be worth about $ by.

The worldwide market for mobile C-arms and fluoroscopy is to grow at slow but steady CAGR of % during the forecast period. Increasing number of hospitals and diagnostic units are the important factors driving the demand for fluoroscopy and mobile C-arms. Rapidly growing aging population in almost all geographic regions has been the major cause of increased number of orthopedic surgeries. The introduction of innovative C-arms for multiple applications is expected to increase the demand for C-arms. Full mobile C-arms have a greater demand than the mini mobile C-arms. The global market for fluoroscopy and C-arm systems had a value of $ and this value is likely to reach $ by.