The Business of Healthcare Innovation

The Business of Healthcare Innovation is a wide-ranging analysis of business trends in the manufacturing segment of the healthcare industry. It provides a thorough overview and introduction to the innovative sectors fueling improvements in healthcare: pharmaceuticals, biotechnology, platform technology, medical devices, and information technology. For each sector, the book examines the basis and trends in scientific innovation, the business and revenue models pursued to commercialize that innovation, the regulatory constraints within which each sector must operate, and the growing issues posed by more activist payers and consumers. Specific topics include market structure and competition, the economics and rationale of product development, pricing, sales and marketing, contract negotiations with buyers, alliances versus mergers, business strategies, and prospects for growth. Written by professors of the Wharton School and industry executives, the book shows why healthcare sectors are such an important source of growth in any nation's economy.

Lawton Robert Burns, Ph.D., MBA is the James Joo-Jin Kim Professor, Professor of Health Care Management and Chair of the Health Care Management Department, and Director of the Center for Health Management and Economics at the Wharton School, University of Pennsylvania.

"Since the first edition of *The Business of Healthcare Innovation*, the workings of the industry have become even more complex, intertwined, and tricky to navigate. The industry's evolution is effectively captured in this successor edition which includes important updates relevant to traditional and newer, 'maverick' innovators who will find the insights and frameworks described to be invaluable."

Peter A. Tollman, Ph.D., Senior Partner and Managing Director, The Boston Consulting Group

"Burns has produced an exceptional successor to *The Business of Healthcare Innovation* with this new edition. The original made an important contribution to those of us who work and invest in the life sciences. The updated and expanded chapters on challenges and possibilities for the pharmaceutical and biotechnology industries, the new insights into the potential of digital health, and the overall theme of convergence of technologies into an innovative model of modern medicine, make it a timely and valuable volume."

G. Steven Burrill, CEO of Burrill & Company

"For an industry that serves the needs of patients with innovative medicines, there are few scholarly books that analyze the underlying business of the life sciences. *The Business of Healthcare Innovation* addresses this important need with a thoughtful and engaging analysis of the pharmaceutical and biotechnology sectors. I particularly enjoyed the discussion on biotech, including discussions on the range of business models and on the symbiotic relationship of biotech companies with pharma. If you're interested in the 'business of science,' this is really worth a read!"

John Maraganore, CEO, Alnylam

"This book is the authoritative text on the medical device industry. The authors combine extensive research with intimate insights to distill a complex topic to its essential ingredients."

Dan Starks, Chairman & CEO, St. Jude Medical

"After decades of anxiety, concerns with healthcare quality, costs and safety have become alarm. Several significant efforts by government and the private sector are underway to transform health care. These efforts center on diverse performance-based reimbursement mechanisms that bind those who provide care with those who purchase care.

As Burns astutely notes these efforts appear to view those organizations that provide products and services to the industry as incidental to the transformation of care. This view is a mistake.

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Frontmatter
More information

Companies that deliver innovative advances in the lifesciences, medical devices and health information technology can be and are significant contributors to our collective efforts to improve care. Vaccines, medical imaging, pacemakers, and electronic health records are examples of these contributions.

The Business of Healthcare Innovation does an exceptional job of describing the nature, challenges and contributions of the companies that produce these products and services. This understanding is essential – effective care transformation requires the efforts of all stakeholders and that each stakeholder understand the nature of the others and how best to form and manage partnerships. Without this understanding care transformation will deliver less than we deserve."

John Glaser, Ph.D., CEO, Siemens Health Services

"It has never been more important to study and understand the medical device sector of the healthcare market. As our U.S. and global healthcare systems transform themselves for the 21st century, the vital medtech industry approaches an important crossroads. Strong forces are arrayed to reshape the way it interacts with patients, clinicians, regulators, payers, and hospitals – in fact, to reshape fundamentally the medical device business model.

This book does an excellent job of breaking down this complicated subject into its unique elements and analyzing each in a clear, direct style that illuminates the key issues facing this rapidly changing industry. The discussion of the sources of, and impediments to, device innovation are particularly welcome. I recommend this astute analysis to healthcare executives, policy-makers, investors, innovators, and anyone else who wants to understand the critical importance and future direction of the medical device industry and medical device innovation."

Michael A. Mussallem, Chairman and CEO, Edwards Lifesciences Corporation

"Innovation is the answer to the cost and quality challenges in health care today. Despite its importance, few scholars have offered a comprehensive assessment of innovation in medicine – what it is, how it arises in specific sectors, and what are the barriers to achieving transformation of health care. This ambitious work makes a substantial contribution to our understanding of this key concept in health care."

Kevin A. Schulman, MD, MBA, Professor of Medicine and Gregory Mario and Jeremy Mario Professor of Business Administration, Duke University

"Health care looms as the central issue for the swarm of baby boomers seeking the goal of wellness in this decade. This primer by Burns and his colleagues nicely summarizes the challenges of developing new technologies that will be relevant and affordable. How will healthcare reform influence the healthcare industry to innovate and invest in new technologies? What will new regulatory approaches do to early stage investment

in new therapies? How will the United States remain a net exporter of medical devices and pharmaceuticals that is the envy of the rest of the world? Can uncommon profitability in the device sector be perpetuated? How are the processes of research and development, collaboration, mergers, and acquisitions different in the pharmaceutical, biotechnology, and medical device industries? The answers can be found in this articulate and well-referenced text."

Stephen Oesterle, MD, Senior Vice-President, Medtronic

"Burns provides an excellent overview of the competitive dynamics of the medical technology sector which has had increasingly significant effects on health service costs and outcomes. Understanding the dynamics of this sector is important for all future healthcare leaders and this comprehensive and accessible book provides first-rate coverage of the subject."

Regina Herzlinger, Ph.D., Professor, Harvard Business School

"Every entrepreneur, no matter whether they be inexperienced or experienced, biotech or device, scientist or business person needs to read *The Business of Healthcare Innovation*. It is not enough today to have a great idea; successful startups require knowledge of the past, present, and future of the our industry if they want a real shot at making a difference."

Mark Levin, Partner and co-founder, Third Rock Ventures

The Business of Healthcare Innovation

Second edition

Edited by

Lawton Robert Burns

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Contents

Figures

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Max A. Kruger works in equity research for Brean Murray Carret and Co., a research-driven boutique investment bank, covering medical technology. Prior to working on Wall Street, Kruger was a healthcare consultant at IMS Health. He has also been involved in projects for Liberty Venture Partners, a venture capital firm specializing in healthcare.

David M. Lawrence served as CEO and Chairman of Kaiser Foundation Health Plan and Hospitals until his retirement in 2002. He currently pursues interests in new business development, teaching, public policy, and writing. He is Senior Venture Partner with Physic Ventures, and a member of the boards of Agilent Technologies, McKesson Corporation, Proventys, Wellpartner, and Proteus Biomed. He is a member of the Health Advisory Boards of the RAND Corporation and, until recently, the Federal Receivership for the California State Prison Health System. He is a Scientific Advisor to Burrill Life Sciences Fund, an advisor to the CEOs of SomaLogic, Inc. and MedExpert, Inc., and teaches with the Estes Park Institute. He consults with selected healthcare systems that pursue advanced integration strategies.

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Jonathan P. Northrup is currently CEO of Beta Cat Pharmaceuticals and Salarius Pharmaceuticals, two translational oncology biotechnology companies working to take novel cancer therapeutics into translational clinical studies. Prior to this, Jon was COO and the first employee for Jubilant Innovation, the venturing group for Jubilant Life Sciences, a major Indian contract services group. In 2005, Jon founded Horizon Biotechnologies, a pharmaceutical consultancy which successfully represented Chinese, Indian, and Korean companies with American and European pharmaceutical companies, and supported Lapatinib clinical trials in China with pharmacogenomics and sample transport and storage services. Until 2004, Jon spent thirty years in the pharmaceutical industry at Eli Lilly and Company. He is author of *Prescription Drug Pricing in Chain and Independent Pharmacies* (1976).

Cary G. Pfeffer is currently a partner at the leading life sciences venture firm Third Rock Ventures, where he drives the firm's overall interface strategy with pharmaceutical and large biotech companies as well as academic institutions. Additionally, he supports the business development efforts within the portfolio companies, and often leads company start-up efforts to build new companies. He currently sits on the boards of Eleven Biotherapeutics, Edimer, Taris Biomedical, and Ablexis. Before joining Third

Rock Ventures, Cary founded the Pfeffer Group in 2002, which provided business development and strategy advisory services for leading biotechnology and life sciences companies. Prior to this he spent over ten years at Biogen in a variety of executive domestic and international management roles focused on business and market development, product development, and commercial operations. Earlier in his career, Cary spent several years in corporate finance in the Health Care Investment Banking Group of Lehman Brothers.

Adam C. Powell is a management consultant in the Health and Life Sciences practice of Oliver Wyman, where he works on issues related to the health insurance, hospital, and pharmaceutical industries. He has published and presented on a range of topics including hospital billing operations, hospital conversions, and resident work hour reductions. Adam holds a Ph.D. from the Wharton School of the University of Pennsylvania.

Stephen M. Sammut has a dual career. He is Senior Fellow, Wharton Entrepreneurial Programs and Health Care Management, where his principal research areas are healthcare and biotech capacity building in the emerging markets, private equity and venture capital approaches to economic development, and the role of the private sector in addressing needs in global health. He is also Venture Partner, Burrill and Company, a global life sciences venture capital fund.

Marina Tarasova is currently a business development professional in Johnson & Johnson's Pharmaceutical Group, supporting the company's pharmaceutical M&A strategy. After beginning her career as a business analyst developing and supporting pharmaceutical and medical device and diagnostic information systems, Marina has held positions in sales, pharmaceutical global marketing strategy, and business development for large pharmaceutical organizations. Her experience has earned her expertise in the immunology, infectious diseases, and cardiovascular disease areas.

Joanna P. Wolkowski works at the Boston Consulting Group (BCG) in the firm's Health Care Practice area. She received her MBA in 2011 from the Wharton School of the University of Pennsylvania, where she completed a double major in Health Care Management and Strategic Management. Joanna also served as Co-Chair for the Seventeenth Annual Wharton Health Care Business Conference.

Abbreviations

A*STAR	Agency for Science, Technology and Research (Singapore)
AAAS	American Association for the Advancement of Science
ACE	angiotensin-converting enzyme
ACO	accountable care organization
ADA	adenosine deaminase deficiency
ADME	absorption, distribution, metabolism, and excretion
AF	atrial fibrillation
AHCA	Agency for Health Care Administration
ALD	adrenoleukodystrophy
AMA	American Medical Association
AMC	academic medical center
ANDA	amended new drug application
API	active pharmaceutical ingredient
ARRA	American Recovery and Reinvestment Act
ASC	ambulatory surgery center
ASP	average selling price
BAK	Bioindustry Association of Korea
BARDA	Biomedical Advanced Research and Development Authority
BCG	Boston Consulting Group
BERIS	Biological and Environmental Research Information System
BLA	biologics licensing application
BMP	bone morphogenetic protein
BPR	business process reengineering
CABG	coronary artery bypass graft
CAF	contract administration fee
CAGR	cumulative average growth rate
CAM	complementary and alternative medicine

CAN	Cares Acceleration Network
CBER	Center for Biologs Evaluation and Research
CDASH	clinical data acquisition standards harmonization
CDER	Center for Drug Evaluation and Research
CDHP	consumer-directed health plan
CDRH	Center for Devices and Radiological Health
CDSS	computerized decision support system
CEDD	center of excellence in drug discovery
CEO	chief executive officer
CER	comparative effectiveness research
CfH	Connecting for Health
CFO	chief financial officer
CGM	continuous glucose monitor
cGMP	current good manufacturing practice
cGxP	current good [ ] practice
CHI	consolidated health informatics
CHIN	community health information network
CHMP	Committee for Medicinal Products for Human Use
CHOP	cyclophosphamide, hydroxydaunorubicin, oncovin, prednisone
CLL	chronic lymphocytic leukemia
CME	continuing medical education
CML	chronic myeloid leukemia
CMO	chief medical officer
CMO	contract manufacturing organization
CMS	Centers for Medicare and Medicaid Services
CNO	chief nursing officer
COGS	cost of goods sold
COMP	Committee for Orphan Medicinal Products
CON	Certificate of Need
COO	chief operating officer
CPOE	computerized physician order entry
CPT	current procedural terminology
CRM	cardiac rhythm management
CRM	customer relationship management
CRO	chief resource officer
CRO	contracted research organization
CSL	clinical science liaison

CSM	clinical science manager
CSO	contract sales organization
CTD	common technical document
CV	cardiovascular
DEB	drug-eluting balloon
DES	drug-eluting stent
DICOM	digital imaging and communications in medicine
DM	disease management
DMF	drug master file
DoD	Department of Defense
DOT	day of therapy
DPP-IV	dipeptidyl peptidase-4
DPU	drug performance unit
DTC	direct to consumer
DTCA	direct to consumer advertising
EBM	evidence-based medicine
EBRI	Employee Benefit Research Institute
eCTD	electronic common technical document
ED	emergency department
EDI	electronic data interchange
EDL	essential drugs list
EFPIA	European Federation of Pharmaceutical Industries and Associations
EHR	electronic health record
EKG	electrocardiogram
EMA	European Medicines Agency (formerly EMEA)
EMEA	European Agency for the Evaluation of Medicinal Products
EMR	electronic medical record
eNPV	expected net present vtalue
EPHI	electronic protected health information
EPO	erythropoietin
EPS	earnings per share
ESC	embryo stem cell
EST	expressed sequence tag
ETP	electronic transmission of prescriptions
F/F/F	form/fill/finish
FASB	Financial Accounting Standards Board
FASEB	Federation of American Societies for Experimental Biology

FDA	Food and Drug Administration
FIBCO	fully integrated bio-pharmaceutical company
FIDDO	fully integrated drug discovery and development organization
FIH	first in human
FIPCO	fully integrated pharmaceutical company
FIPNet	fully integrated pharmaceutical network
FOB	follow-on biologic
FSS	Federal Supply Schedule
FTC	Federal Trade Commission
GAO	Government Accountability Office
GCP	good clinical practice
G-CSF	granulocyte-colony stimulating factor
GINA	Genetic Information Nondiscrimination Act
GLP	good laboratory practice
GLP-1	glucagon-like peptide-1
GMP	good manufacturing practice
GPO	group purchasing organization
GWA	genome-wide association
GxP	good [ ] practice
HBA1c	haemoglobin A1c
HCV	hepatitis C virus
HDL	high-density lipoprotein
HGS	Human Genome Sciences
HIE	health information exchange
HINTS	Health Information National Trends Survey
HIPAA	Health Insurance Portability and Accountability Act 1996
HITECH	Health Information Technology for Economic and Clinical Health
HIV	human immunodeficiency virus
HMO	health maintenance organization
HSA	health savings account
HTAs	health technology assessments
HTS	high-throughput screening
ICD	international classification of diseases
ICH	International Conference on Harmonization of Technical Requirements for Registration of Pharmaceuticals for Human Use

ICSI	Institute for Clinical Systems Improvement
IDE	investigative device exemption
IDN	integrated delivery network
IHI	Institute for Healthcare Improvement
INCJ	Innovation Network Corporation of Japan
IND	investigational new drug
IO	industrial organization
IPA	independent practitioner association
IPO	initial public offering
iPS	inducible pluripotent stem cells
IRB	Institutional Review Board
IT	information technology
JPMA	Japanese Pharmaceutical Manufacturers Association
KBRA	Korea Biotechnology Research Association
KOBIOVEN	Korea Bio Venture Association
KOL	key opinion leader
LDL	low-density lipoprotein
M&A	merger and acquisition
mAb	monoclonal antibody
MAD	multiple ascending dose
MCO	managed care organization
MEP	market exclusivity period
MHLW	Ministry of Health, Labor, and Welfare (Japan)
MPRA	Munich Personal Research Papers in Economics Archive
mRNA	messenger ribonucleic acid
mTOR	mammalian target of rapamycin
NBRA	National Biotechnology Regulatory Authority (India)
NCE	new chemical entity
NDA	new drug application
NEWBio	new biotech company
NHI	National Health Insurance (Japan)
NHIN	Nationwide Health Information Network
NICE	National Institute of Health and Clinical Excellence (UK)
NIH	National Institutes of Health
NME	new molecular entity
NPfIT	National Programme for IT
NPP	new product planning

NPV	net present value
NRDO	no research, development only
OCP	Office of Combination Products
OER	Office of Extramural Research
OPPAGA	Office of Program Policy Analysis and Government Accountability
OTC	over the counter
OTCD	ornithine transcarbamylase deficiency
PACS	picture archiving and communications system
PBM	pharmacy benefit management
PBMs	pharmacy benefit managers
PCI	percutaneous coronary intervention
PCR	polymerase chain reaction
PDL	preferred drug list
PDUFA	Prescription Drug User Fee Act
PET	positron emission tomography
PHR	personal health record
PhRMA	Pharmaceutical Research and Manufacturers of America
PICC	peripherally inserted central catheter
PIPE	private investment in public equity
PMA	pre-market approval
PML	progressive multifocal leukoencephalopathy
PMOA	primary model of action
PoC	proof of concept
POS	point of service
PPACA	Patient Protection and Affordable Care Act
PPAR	peroxisome proliferator-activated receptor
PPI	physician preference item
PPO	preferred provider organization
PTCA	percutaneous transluminal coronary angioplasty
QALY	quality-adjusted life year
R&D	research and development
R&DLP	research and development limited partnership
RAC	Recombinant DNA Advisory Committee
RBV	resource-based view
RDD	rational drug design
rDNA	recombinant DNA
REMS	risk evaluation and mitigation strategy

RFID	radio frequency identification
RHIO	regional health information organization
RIPCO	royalty-income [*also* research-intensive] pharmaceutical company
RN	registered nurse
RNA	ribonucleic acid
RNAi	RNA interference
ROI	return on investment
RSV	respiratory syncytial virus
Rx	prescription drug
SaaS	software as a service
SAD	single ascending dose
SAR	structure–activity relationship
SARS	severe acute respiratory syndrome
SBIR	Small Business Innovative Research
SCID	severe combined immunodeficiency
SEC	Securities and Exchange Commission
SFDA	State Food and Drug Administration (China)
SFE	sales force effectiveness
SG&A	selling, general, and administrative
Sino FDA	Chinese Food and Drug Administration
siRNA	small interfering ribonucleic acid
SKU	stock-keeping unit
SNP	single nucleotide polymorphism
SOC	standard of care
SPE	special-purpose enterprise
STTR	Small Business Technology Transfer
SWORD	stock warrant offer for research and development
TCM	traditional Chinese medicine
TCT	transcatheter cardiovascular therapeutics
TNF	tumor necrosis factor
tPA	tissue plasminogen activator
TRIPS	Agreement on Trade-Related Aspects of Intellectual Property Rights (China)
TZD	thiazolidinedione
UCR	usual, customary, and reasonable
uHTS	ultra high-throughput screening

VA	Veterans Affairs
VAD	ventricular assist device
VBP	value-based purchasing
VC	venture capital
WTO	World Trade Organization