Hyperbaric Oxygen Therapy for Tissue Damage

Scheduled Presentations

	Name/ Representing
1	Karen Stanek, MD NW Medical Rehabilitation

Disclosure

Any unmarked topic will be considered a "Yes"

	Potential Conflict Type	Yes	No
1.	Salary or payments such as consulting fees or honoraria in excess of $10,000.	✓	
2.	Equity interests such as stocks, stock options or other ownership interests.		✓
3.	Status or position as an officer, board member, trustee, owner.		✓
4.	Loan or intellectual property rights.		✓
5.	Research funding.		✓
6.	Any other relationship, including travel arrangements.		✓

If yes, list name of organizations that relationship(s) are with and for #6, describe other relationship:

Spokane Hyperbarics - employee

	Potential Conflict Type	Yes	No
7.	Representation: if representing a person or organization, include the name and funding sources (e.g. member dues, governmental/taxes, commercial products or services, grants from industry or government).	✓	

If yes to #7, provide name and funding Sources: Spokane Hyperbarics - I'm an employee - Funding not provided to come to this meeting

If you believe that you do not have a conflict but are concerned that it may appear that you do, you may **attach additional sheets** explaining why you believe that you should not be excluded.

I certify that I have read and understand this Conflict of Interest Form and that the information I have provided is true, complete, and correct as of this date.

X Karen Stanek 3/1/2013 KAREN STANEK

Signature Date Print Name

For questions contact: Christine Masters
Health Technology Assessment
PO Box 42712
Olympia, WA 98504-2712
360-725-5126

Disclosure

Any unmarked topic will be considered a "Yes"

	Potential Conflict Type	Yes	No
1.	Salary or payments such as consulting fees or honoraria in excess of $10,000.		✓
2.	Equity interests such as stocks, stock options or other ownership interests.		✓
3.	Status or position as an officer, board member, trustee, owner.		✓
4.	Loan or intellectual property rights.		✓
5.	Research funding.		✓
6.	Any other relationship, including travel arrangements.		✓

If yes, list name of organizations that relationship(s) are with and for #6, describe other relationship:

	Potential Conflict Type	Yes	No
7.	Representation: if representing a person or organization, include the name and funding sources (e.g. member dues, governmental/taxes, commercial products or services, grants from industry or government).		✓

If yes to #7, provide name and funding Sources: _____

If you believe that you do not have a conflict but are concerned that it may appear that you do, you may **attach additional sheets** explaining why you believe that you should not be excluded.

I certify that I have read and understand this Conflict of Interest Form and that the information I have provided is true, complete, and correct as of this date.

X _____ 3/1/2013 NEIL B. HAMPSON, MD

Signature *Date* *Print Name*

For questions contact: Christine Masters
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PO Box 42712
Olympia, WA 98504-2712
360-725-5126

CURRICULUM VITAE

Neil Bradley Hampson, MD

PERSONAL DATA

Date of Birth	May 17, 1955
Place of Birth	Seattle, Washington
Citizenship	United States
Address	42306 N. Caledonia Way Anthem, AZ 85086
	131 Utsalady Road Camano Island, WA 98282

EDUCATION

University of Washington, Seattle, WA	
Bachelor of Science - Cellular and Molecular Biology	1973-1977
University of Washington School of Medicine	
Doctor of Medicine	1977-1981

INTERNSHIP, RESIDENCY AND FELLOWSHIP

University of Iowa Hospitals and Clinics,	
Intern; Internal Medicine	1981-1982
University of Iowa Hospitals and Clinics,	
Resident; Internal Medicine	1982-1984
Duke University Medical Center,	
Fellow; Allergy, Critical Care and Respiratory Medicine	1984-1987

ADDITIONAL TRAINING

Hyperbaric Medicine Team Training, Southwest Texas Methodist Hospital,	
San Antonio	1989
NOAA-UHMS Diving and Hyperbaric Medicine Training Program,	
NOAA Diving Center, Seattle	1990
Ethical Conduct of Research with Human Subjects Training Course,	
Fred Hutchinson Cancer Research Center, Seattle	2001
UHMS Medical Assessment of Fitness for Diving Training Course,	
Seattle	2006

CERTIFICATION

Diplomate, National Board of Medical Examiners	1982
Diplomate, American Board of Internal Medicine (095339)	1984
Diplomate, Pulmonary Disease (095339)	1988
Diplomate, Critical Care Medicine (095339)	1989
Diplomate, Undersea and Hyperbaric Medicine (001042)	2000, 2010
UHMS Approved Diving Medical Examiner	2006

FACULTY APPOINTMENTS

Associate in Medicine	
Division of Allergy, Critical Care and Respiratory Medicine	
Duke University Medical Center, Durham, NC	1987-1988
Clinical Instructor in Medicine	
Division of Pulmonary and Critical Care Medicine	
University of Washington, Seattle, WA	1990-1992
Clinical Assistant Professor of Medicine	
Division of Pulmonary and Critical Care Medicine	
University of Washington, Seattle, WA	1992-1998
Clinical Associate Professor of Medicine	
Division of Pulmonary and Critical Care Medicine	
University of Washington, Seattle, WA	1998-2004
Clinical Professor of Medicine	
Division of Pulmonary and Critical Care Medicine	
University of Washington, Seattle, WA	2004-date

PROFESSIONAL SOCIETY MEMBERSHIPS

American College of Physicians-American Society of Internal Medicine, Fellow	1982
American College of Chest Physicians, Fellow	1984
American Thoracic Society	1984
Undersea and Hyperbaric Medical Society	1989
American Medical Association	1992

PROFESSIONAL LICENSURE

Iowa	#23110	(Inactive)
North Carolina	#28503	(Inactive)
Washington	#0025280	(Active)

PRESENT POSITIONS AND APPOINTMENTS

Member, Hyperbaric Oxygen Therapy Committee, Undersea and Hyperbaric Medical Society	1995-date
Member, Examination Committee of the American Board of Preventive Medicine, Subcommittee for the Undersea and Hyperbaric Medicine Examination	1999-date
Member, Editorial Board, *Undersea and Hyperbaric Medicine*	2000-date
Member, Board of Directors, Research Foundation, Undersea and Hyperbaric Medical Society	2004-date
Past-President, Undersea and Hyperbaric Medical Society	2006-date
Member, National Carbon Monoxide EPHT Surveillance Group, Centers for Disease Control and Prevention	2006-date
Physician Emeritus, Virginia Mason Medical Center, Seattle, WA	2010-date

VISITING PROFESSORSHIPS

Stanford University, Palo Alto, California	1993
Karolinska Institute, Stockholm, Sweden	1997
University of Iowa, Iowa City, Iowa	1999

AD HOC REVIEWER

American Journal of Respiratory and Critical Care Medicine, British Journal of Sports Medicine, Disaster Medicine, Diving and Hyperbaric Medicine, International Journal of Environmental Health Research, JAMA, Journal of Applied Physiology, Journal of Emergency Medicine, Journal of Injury and Violence Research, Journal of Internal Medicine, Journal of Respiratory Diseases, New England Journal of Medicine, Respiratory Care, The Lancet, Undersea & Hyperbaric Medicine

PATENTS

Non-Invasive Method for Detecting Deep Venous Thrombosis in the Human Body. 1994 United States Patent #5,282,467.

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PAST POSITIONS AND APPOINTMENTS

Member, Health Care Policy and Clinical Practice Committee, American Thoracic Society	1992-1993
Reviewer, Critical Care Medicine Examination, American Board of Internal Medicine	1994
Chairman, Scientific Program, Undersea and Hyperbaric Medical Society Annual Meeting	1995
Member at Large, Executive Committee, Undersea and Hyperbaric Medical Society	1994-1997
Member, Carbon Monoxide Work Group, Environmental Task Force, Steering Committee for Surveillance Case Definitions for Noninfectious Conditions, Centers for Disease Control and Prevention	1997-1998
Secretary, Undersea and Hyperbaric Medical Society Pacific Chapter	1998-1999
Member, Research Advisory Committee, Virginia Mason Research Center, Seattle, WA	1991-1999
Chairman, Research Advisory Committee, Virginia Mason Research Center, Seattle, WA	1994-1999
Member, Continuing Education Committee, Washington Thoracic Society	1995-1999
Co-Chair, "*Illuminations 2000*", Gala Benefit for the Virginia Mason Research Center	2000
Chairman, Hyperbaric Oxygen Therapy Committee, Undersea and Hyperbaric Medical Society	1996-2000
President-Elect, Undersea and Hyperbaric Medical Society Pacific Chapter	1999-2000
Member at Large, Executive Committee, Washington Thoracic Society	1999-2001
Team Pulmonologist, Seattle Storm (WNBA)	2001
Co-Chair, "*Dreambuilders' Ball 2002",* Gala Benefit for Virginia Mason Medical Center	2002
President-Elect, Undersea and Hyperbaric Medical Society	2000-2002
Chair, Nominating Committee, Undersea and Hyperbaric Medical Society	2000-2002
Member, Organizing Committee, *Oxygen 2002: An International Symposium on Oxygen*	2001-2002
Deputy Medical Director, Respiratory Therapy Department, Virginia Mason Medical Center, Seattle, WA	1991-2002
Vice President, Benaroya Research Institute at Virginia Mason, Seattle, WA	2000-2003
Member, Operations Committee, Undersea and Hyperbaric Medical Society	2000-2004
President, Undersea and Hyperbaric Medical Society	2002-2004
Chair, GlaxoSmithKline Pulmonary Fellowship Advisory Board	1990-2005
Member, Board of Directors, Benaroya Research Institute at Virginia Mason, Seattle, WA	2000-2005
Chair, Website Committee, Undersea and Hyperbaric Medical Society	2005-2006
Member, Board of Directors, University of Washington School of Medicine Alumni Association	1992-2006

PAST POSITIONS AND APPOINTMENTS (continued)

Head, Section of Pulmonary and Critical Care Medicine, Virginia Mason Medical Center, Seattle, WA	1999-2006
Immediate Past-President, Undersea and Hyperbaric Medical Society	2004-2006
Member, Board of Directors, Undersea and Hyperbaric Medical Society	1994-2008
Attending Physician, Section of Pulmonary and Critical Care Medicine, Virginia Mason Medical Center, Seattle, WA	1988-2010
Medical Director, Center for Hyperbaric Medicine, Virginia Mason Medical Center, Seattle, WA	1989-2010
Regional Coordinator, Northwestern Region, Divers Alert Network	1989-2010
Consulting Physician, Divers Alert Network	1989-2010
Member, Federal and Regulatory Affairs Task Force, Undersea and Hyperbaric Medical Society	2000-2010
Member, State of Washington Building Council Technical Advisory Goup on Residential Carbon Monoxide Alarms	2011

GRANT SUPPORT

National Institutes of Health, National Research Service Award, HL07538-04, Trainee	1984-1986
American Lung Association Research Grant "The Effect of Diffuse Lung Injury and PEEP on Tissue Oxygen Metabolism" Principal Investigator, $35,000	1986-1988
National Institutes of Health, R01-NS24535-01 "Non-Invasive Monitoring of O2 Delivery During Brainwork" Co-Investigator (50% effort), $496,189 Y01-02	1986-1988

AWARDS AND HONORS

Phi Beta Kappa	1977
Magna cum Laude, University of Washington	1977
University of Washington Medical Student Research Training Program Fellowship	1977
University of Washington School of Medicine Alumni Association Fellowship	1978
Medical Thesis Honors, University of Washington School of Medicine	1980
RH Williams Medical Research Award	1980
Research Training Fellowship Award, American Lung Association/ American Thoracic Society	1986-1988
Teacher of the Year. Virginia Mason Medical Center House Staff Award	1991
Department of Medicine Teacher of the Month. Virginia Mason Medical Center	1993
Rochester Academy of Medicine Award	1996

Distinguished Service Award, Undersea and Hyperbaric Medical Society	1997
Seattle-King County American Red Cross 1998 Hero Award	1998
Champion of Washington State Award, named by Lieutenant Governor Brad Owen	1998
Certificate of Recognition for Participation in Ambulatory Teaching, American College of Physicians-American Society of Internal Medicine	1999
Listed in "The Consumers' Guide to the Top Doctors in the U.S."	1999, 2000, 2003
Listed in "Best Doctors", Seattle Magazine	2000, 2005
Listed in "The Guide to Top Doctors"	2002, 2004
Listed in "Guide to America's Top Physicians"	2003-2009
Award for Contributions to the Advancement of Hyperbaric Medicine Winter Hyperbaric Medicine Symposium	2006
Paul Bert Award, Undersea and Hyperbaric Medical Society	2006
Washington State Adjuvant General Outstanding Performance Medal, Awarded by Major General Lowenstein	2007
James Tate Mason Award, Virginia Mason Medical Center	2007
Washington Thoracic Society Outstanding Clinician Award	2008
Best Scientific Paper, Undersea and Hyperbaric Medical Society Annual Scientific Meeting	2009
Merrill P Spencer Lifetime Achievement Award for Significant Contribution to the Advancement of Undersea Science and Hyperbaric Medicine	2009
The Boerema Award for Exceptional Contributions to the Field of Hyperbaric Medicine	2009
Carolyn Sue Ray Award for Excellence in Hyperbaric Medicine in Areas Impacting Patient Care, Undersea and Hyperbaric Medical Society	2010
Ronald Bangasser Honorary Lecturer, Undersea and Hyperbaric Medical Society Annual Scientific Meeting, Fort Worth, Texas	2011

PUBLICATIONS

ARTICLES AND CHAPTERS

Hampson NB. Control of the pituitary-thyroid axis in cold stress. Medical Thesis, University of Washington School of Medicine. Approved May, 1980.

Hampson NB, Piantadosi CA, Jöbsis-VanderVliet FF. Near infrared optical monitoring of cat skeletal muscle during hypercapnia. *Adv Exp Med Biol* 1986;200:523-530.

Hampson NB, Jöbsis-VanderVliet FF, Piantadosi CA. Skeletal muscle oxygen availability during respiratory acid-base disturbances in cats. *Respir Physiol* 1987;70:143-158.

Hampson NB, Piantadosi CA. NIR monitoring of human skeletal muscle oxygenation during forearm ischemia. *J Appl Physiol* 1988;64:2449-2457.

Collaborative Group on Intracellular Monitoring. Intracellular monitoring of experimental respiratory failure. *Am Rev Respir Dis* 1988;138:484-487.

Hampson NB, Piantadosi CA. Rheumatoid lung disease. In: Cherniack RM, ed. *Current Therapy of Respiratory Disease - 3*. Philadelphia: B.C. Decker Inc.; 1989; 226-229.

Hampson NB, Piantadosi CA. Near infrared optical responses in feline brain and skeletal muscle tissues during respiratory acid-base imbalance. *Brain Res* 1990;519:249-254.

Hampson NB, Winterbauer RH. Reducing the risk of pneumothorax when you give TPN via the subclavian vein. *J Crit Illness* 1990;5:534-538.

Hampson NB, Camporesi EM, Stolp BW, Moon RE, Shook JE, Griebel JA, Piantadosi CA. Cerebral oxygen availability by NIR spectroscopy during transient hypoxia in humans. *J Appl Physiol* 1990;69:907-913.

Schmidt RA, Glenny RW, Godwin JD, Hampson NB, Cantino ME, Reichenbach DD. Panlobular emphysema in young intravenous Ritalin abusers. *Am Rev Respir Dis* 1991;143:649-656.

Hampson NB, Woolf RA, Springmeyer SC. Oral antibiotics for pneumonia. *Clin Chest Med* 1991;12:395-407.

Hampson NB, Norkool DM. Carbon monoxide poisoning in children riding in the back of pickup trucks. *JAMA* 1992;267:538-540. Reprinted in: *Curr Mun Problems* 1992;19:44-52.

Hampson NB, Dunford RG, Norkool DM. Treatment of carbon monoxide poisonings in multiplace hyperbaric chambers. *J Hyperbaric Med* 1992;7:165-171.

Hampson NB. Clinical aspects of carbon monoxide poisoning. In: Camporesi EM, Vezzani G, Pizzola A, eds. *The Realm of Hyperbaric Therapy: Proceedings of the International Congress on Hyperbaric Medicine*. Parma: Fidenze; 1992;221-225.

Hampson NB, Kramer CC, Copass MK, et al. Unintentional carbon monoxide poisoning following a winter storm - Washington, January 1993. *MMWR* 1993;42:109-111. Reprinted in: *JAMA* 1993;269:1372-1373.

Norkool DM, Hampson NB, Gibbons RP, Weissman RM. Hyperbaric oxygen therapy for radiation-induced hemorrhagic cystitis. *J Urol* 1993;150:332-334.

Hampson NB, Kramer CC, Dunford RG, Norkool DM. Accidental carbon monoxide poisoning resulting from indoor burning of charcoal briquets. *JAMA* 1994;271:52-53.

Hampson NB, Mueller MP. Reduction in patient timing errors utilizing a breath-activated metered dose inhaler. *Chest* 1994;106:462-465.

Hampson NB. Selection criteria and hyperbaric treatment protocols for severe carbon monoxide poisoning: What are the problems? In: Wattel F, ed. *First European Consensus Conference on Hyperbaric Medicine.* Lille University Medical Center, Lille, France; 1994;78-90.

Hampson NB, Dunford RG, Kramer CC, Norkool DM. Selection criteria utilized for hyperbaric oxygen treatment of carbon monoxide poisoning. *J Emerg Med* 1995;13:227-231.

Silvers SM, Hampson NB. Accidental carbon monoxide poisoning in recreational boaters. *JAMA* 1995;274:1614-1616.

Hampson NB. Epidemiology and treatment of acute carbon monoxide intoxication in the United States. In: Camporesi EM, Caroli GC, Pizzola A, Vezzani G, eds. *Proceedings of the International Symposium on Hyperbaric Oxygen Therapy.* Bologna, Italy; 1995;121-129.

Hampson NB. Outcome of carbon monoxide-intoxicated patients presenting in coma. In: Camporesi EM, Caroli GC, Pizzola A, Vezzani G, eds. *Proceedings of the International Symposium on Hyperbaric Oxygen Therapy.* Bologna, Italy; 1995; 156-159.

Hampson NB. Pulmonary embolism: Difficulties in the clinical diagnosis. *Semin Respir Infect* 1995;10:123-130.

Hampson NB. Carbon monoxide poisoning at an indoor ice arena and bingo hall - Seattle, 1996. *MMWR* 1996;45:265-267. Reprinted in: *JAMA* 1996;275:1468-1469.

Winterbauer RH, Hampson NB, Kirtland SH, Pardee NE, *et al*. Clinicians performing research: A brief synopsis of one section's 45-year tradition. *Vir Mason Med Ctr Bull* 1996;50:29-37.

Hampson NB. Carbon monoxide poisoning in the United States. In: Oriani G, Marroni A, Wattel F, eds. *Handbook on Hyperbaric Medicine.* Berlin: Springer-Verlag; 1996;297-304.

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Hampson NB, Simonson SG, Kramer CC, Piantadosi CA. Central nervous system oxygen toxicity during hyperbaric treatment of patients with carbon monoxide poisoning. *Undersea Hyperb Med* 1996;23:215-219.

Hampson NB, Dunford RG. Pulmonary edema of scuba divers. *Undersea Hyperb Med* 1997;24:29-33.

Kirtland SH, Corley DE, Winterbauer RH, Springmeyer SC, Casey KR, Hampson NB, Dreis DF. The diagnosis of ventilator-associated pneumonia: A comparison of histologic, microbiologic, and clinical criteria. *Chest* 1997:112:445-457.

Hampson NB, Panacek EA, Tapson VF, Begany T. Pulmonary embolism: Common, elusive, and deadly. *Patient Care* 1997;31:75-88.

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Keenan HT, Bratton SL, Norkool DM, Brogan TV, Hampson NB. Delivery of hyperbaric oxygen therapy to critically ill, mechanically ventilated children. *J Crit Care* 1998;13:7-12. Reprinted with permission in: Vezzani G, ed. *Medicina Subacquea ed Iperbarica.* Parma, Italy; 1998;133-138.

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Hampson NB. Pulse oximetry in severe carbon monoxide poisoning. *Chest* 1998;114:1036-1041.

Ball LB, Macdonald,SC, van Assendelft OW, Astles JR, McCammon J, Heumann M, Fleissner ML, Toal B, Hampson NB. Surveillance Case Definition for Acute Carbon Monoxide Poisoning. http://www.cste.org/ps/1998/1998-eh-01.htm

Hyperbaric Oxygen Therapy Committee. Hyperbaric Oxygen Therapy: 1999 Committee Report. Hampson NB, ed. Kensington, MD: Undersea and Hyperbaric Medical Society; 1999.

Ralston JD, Hampson NB. Incidence of severe unintentional carbon monoxide poisoning differs across racial/ethnic categories. *Public Health Reports* 2000;115:46-51.

Raub JA, Mathieu-Nolf M, Hampson NB, Thom SR. Carbon monoxide poisoning: A public health perspective. *Toxicology* 2000;145:1-14.

Geltzer AJ, Geltzer AMB, Dunford RG, Hampson NB. Effects of weather on incidence of attempted suicide by carbon monoxide poisoning. *Undersea Hyperb Med* 2000;27:9-14.

Hampson NB. Carbon monoxide poisoning and its management in the United States. In: Penney DG, ed. *Carbon Monoxide Toxicity*. Boca Raton, Florida: CRC Press; 2000:193-203.

Duchin JS, Koehler J, Kobayashi JM, Rakita RM, Olson K, Hampson NB, *et al*. Legionnaires' Disease Associated With Potting Soil - California, Oregon, and Washington, May--June 2000. *MMWR* 2000;49:777-778.

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Dunford RG, Salbador GW, Mejia EB, Hampson NB. Dive profiles and results of treatment (in Miskito Indian lobster divers). In: Lepawski M, Wong R, eds. Empirical diving techniques of commercial sea harvesters. Proceedings of the Fiftieth Workshop of the Undersea and Hyperbaric Medical Society. Kensington, Maryland: Undersea and Hyperbaric Medical Society, 2001:11-16.

Hampson NB, Zmaeff JL. Outcome of patients experiencing cardiac arrest with carbon monoxide poisoning and treated with hyperbaric oxygen. *Ann Emerg Med* 2001;38:36-41.

Hampson NB, Mathieu D, Piantadosi CA, Thom SR, Weaver L. Carbon monoxide poisoning: Interpretation of randomized clinical trials and unresolved treatment issues. *Undersea Hyperb Med* 2001;28:157-164.

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Hampson NB, Hampson LA. Characteristics of the headache associated with acute carbon monoxide poisoning. *Headache* 2002;42:220-223.

Backous DD, Dunford RG, Segal P, Muhlocker C, Carter P, Hampson NB. Effects of hyperbaric exposure on the integrity of the internal components of commercially available cochlear implant systems. *J Otol Neurotol* 2002;23:463-467.

Feldmeier JJ, Hampson NB. A systematic review of the literature reporting the application of hyperbaric oxygen prevention and treatment of delayed radiation injuries: An evidence based approach. *Undersea Hyperb Med* 2002;29:4-30.

Dunford RG, Mejia EB, Salbador GW, Gerth WA, Hampson NB. Diving methods and

decompression sickness incidence of the Miskito Indian underwater harvesters. *Undersea Hyperb Med* 2002;29:74-85.

Corman JM, McClure RD, Pritchett TR, Kozlowski P, Hampson NB. Treatment of radiation-induced hemorrhagic cystitis with hyperbaric oxygen. *J Urol* 2003; 169:2200-2202.

Hampson NB, Atik DA. Central nervous system oxygen toxicity during routine hyperbaric oxygen therapy. *Undersea Hyperb Med* 2003; 30:147-153.

Hyperbaric Oxygen Therapy Committee. Hyperbaric Oxygen 2003: Indications and Results. The Hyperbaric Oxygen Therapy Committee Report. Feldmeier JJ, ed. Kensington, MD: Undersea and Hyperbaric Medical Society; 2003.

Hampson NB, Pollock NW, Piantadosi CA. Oxygenated water and athletic performance. *JAMA* 2003;290: 2497-2498.

Wreford-Brown CE, Hampson NB. Hyperbaric oxygen treatment protocols for mandibular osteoradionecrosis. *Undersea Hyperb Med* 2003; 30:175-179.

Chong KT, Hampson NB, Bostwick DG, Vessella RL, Corman JM. Hyperbaric oxygen does not accelerate latent in vivo prostate cancer: Implications for the treatment of radiation-induced hemorrhagic cystitis. *Br J Urol Int* 2004; 94: 1275-1278.

Hampson NB, Zmaeff JL. Carbon monoxide poisoning from portable electric generators. *Am J Preventive Med* 2005; 28:123-125.

Bennett MH, Feldmeier J, Hampson N, Smee R, Milross C. Hyperbaric oxygen therapy for late radiation tissue injury. *The Cochrane Database of Systematic Reviews* 2005, Issue 3. Art. No.: CD005005.pub2. DOI: 10.1002/14651858.CD005005.pub2.

Hampson NB, Little CE. Hyperbaric treatment of patients with carbon monoxide poisoning in the United States. *Undersea Hyperb Med* 2005; 32:21-26.

Doherty MJ, Hampson NB. Partial seizure provoked by hyperbaric oxygen therapy: possible mechanisms and implications. *Epilepsia* 2005; 46(6):974-976.

Chong KT, Hampson NB, Corman JM. Early hyperbaric oxygen therapy improves outcome for radiation-induced hemorrhagic cystitis. *J Urol* 2005; 65:649-653.

Hampson NB, Lai MW, McNeil M, Byers P, Ratard R, *et al.* Carbon monoxide poisoning after Hurricane Katrina – Alabama, Louisiana, and Mississippi, August-September 2005. *MMWR* 2005; 54:1-3.

Hampson NB. Trends in the incidence of carbon monoxide poisoning in the US. *Am J Emerg Med* 2005; 23:838-841.

Hampson NB, Dunford RG, Ross DE, Wreford-Brown CE. A prospective, randomized clinical trial comparing two hyperbaric treatment protocols for carbon monoxide poisoning. *Undersea Hyperb Med* 2006; 33:27-32.

National Workgroup on Carbon Monoxide Surveillance. Carbon monoxide: A model environmental public health indicator. April, 2006; available from Judith.Graber@maine.gov

Hampson NB, Weaver LK. Noninvasive CO measurement by first responders: A suggested management algorithm. *J Emerg Med Serv* 2006; 24(Suppl):10-12.

Dall'Era MA, Hampson NB, Hsi RA, Madsen B, Corman JM. Hyperbaric oxygen therapy for radiation-induced proctopathy in men with prostate cancer. *J Urol* 2006; 176:87-90.

Hampson NB, Scott KL, Zmaeff JL. Carboxyhemoglobin measurement by hospitals: Implications for the diagnosis of carbon monoxide poisoning. *J Emerg Med* 2006; 31(1): 13-16.

Hampson NB, Ecker ED, Scott KL. Use of a noninvasive pulse CO-oximeter to measure blood carboxyhemoglobin levels in bingo players. *Respiratory Care* 2006; 51(7): 758-760.

Hampson NB, Stock AL. Storm-related carbon monoxide poisoning: Lessons learned from recent epidemics. *Undersea Hyperb Med* 2006; 33:257-263.

Mendoza JA, Hampson NB. Epidemiology of severe carbon monoxide poisoning in children. Undersea Hyperb Med 2006; 33:439-446.

Marshall GT, Thirlby RC, Bredfeldt JE, Hampson NB. Treatment of gastrointestinal radiation injury with hyperbaric oxygen. *Undersea Hyperb Med* 2007; 34:35-42.

Hampson NB, Weaver LK. Carbon monoxide poisoning: A new incidence for an old disease. *Undersea Hyperb Med* 2007; 34(3):163-168.

Hampson NB. Carboxyhemoglobin elevation due to hemolytic anemia. *J Emerg Med* 2007; 33(1):17-19.

Hampson NB, Corman JM. Rate of delivery of hyperbaric oxygen treatments does not affect response in soft tissue radionecrosis. *Undersea Hyperb Med* 2007; 34(5):329-334.

Hampson NB. Noninvasive measurement of blood carboxyhemoglobin with pulse CO-oximetry. In: Penney DG, ed. *Carbon Monoxide Poisoning*. Boca Raton, Florida: CRC Press; 2007: 739-744.

Mahoney AM, Stimpson CL, Scott KL, Hampson NB. Noninvasive measurement of

carboxyhemoglobin levels for adjustment of diffusion capacity measured during pulmonary function testing. *Respir Care* 2007; 52(12):1741-1743.

Hampson NB. Stability of carboxyhemoglobin in stored and mailed blood samples. *Am J Emerg Med* 2008; 26:191-195.

Crawford DM, Hampson NB. Fire and ice: Diagnosis of carbon monoxide poisoning in an extreme environment. *Emerg Med J* 2008; 25:235-236.

Hampson NB, Johnson AL, Hampson DF. Sputum color: Potential implications for clinical practice. *Respir Care* 2008; 53(4):450-454.

Hampson NB, Hauff NM. Carboxyhemoglobin levels in carbon monoxide poisoning: Do they correlate with the clinical picture? *Am J Emerg Med* 2008; 26(6):665-669.

Gerbino A, Hampson NB. Multiplace hyperbaric chambers. In: Neuman T, Thom SR, eds. *Physiology and Medicine of Hyperbaric Oxygen Therapy*. New York: Elsevier, Inc; 2008: in press.

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Hampson NB, Hauff NM, Rudd RA. Increased long-term mortality among survivors of acute carbon monoxide poisoning. *Crit Care Med* 2009; 37(6):1941-1947.

Gulati R, Kwan-Gett T, Hampson NB, Baer A, Shusterman D, Shandro J, Duchin J. A carbon monoxide epidemic among immigrant populations: King County, Washington, 2006. *Am J Pub Health* 2009; 99(9):1687-1692. Epub 2009 Jul 16.

Hampson N, Dunn S, Bronstein A, Fife C, Villanachi J, *et al*. Carbon monoxide exposures after Hurricane Ike – September 2008. *MMWR* 2009; 59:845-847.

Fife CE, Smith L, Maus E, O'Malley E, Hampson NB. Dying to play video games: Carbon monoxide poisoning from electrical generators following hurricane Ike. *Pediatrics*; 2009 Jun;(6): e1035-e1038.

Snyder S, Beshlian K, Hampson NB. Hyperbaric oxygen and reduction mammaplasty in the previously irradiated breast. *Plastic Recons Surg* 2010: 125(6):255e-257e.

Bennett M, Mitchell S, Neuman T, Piantadosi CA, Feldmeier J, Hampson NB, Smart D, Wilkinson D, Bryson P. Hyperbaric oxygen and neurological diseases. *Undersea Hyperb Med* 2010; 37(5):371-373.

Hampson NB, Holm JR. Hyperbaric oxygen for chronic radiation tissue injury. *Virginia Mason Medical Center Bulletin* 2010; 64:43-47.

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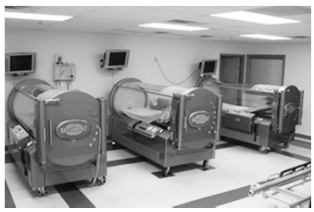
Washington State Health Care Authority

Hyperbaric Oxygen Therapy for Tissue Damage, Including Wound Care and Treatment of Central Nervous System Conditions

State Agency Utilization & Outcomes

Kerilyn K. Nobuhara MD MHA
Senior Medical Consultant
Health Care Authority
March 22, 2013

Hyperbaric Oxygen Therapy: Background



- Systemic treatment with 100% oxygen
- > 1 atmosphere
- Single or multiple patient chambers
- Acute conditions excluded:
  - Decompression illness
  - Carbon monoxide intoxication
  - Cyanide poisoning
  - Gas embolism
  - Gas gangrene
  - Progressive necrotizing infections

2

Washington State Health Care Authority

Hyperbaric Oxygen Therapy : Background

- CPT 99183
  - Physician or other qualified health care professional attendance and supervision of hyperbaric oxygen therapy, per session
- HCPCS C 1300
  - Hyperbaric oxygen under pressure, full body chamber, per 30 minute interval

3

Washington State Health Care Authority

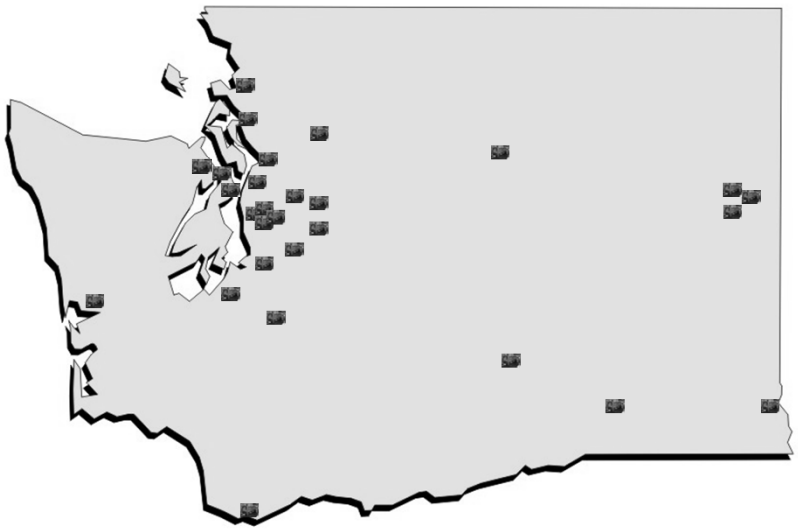
Hyperbaric Oxygen Therapy : Background

- Chambers under 510(k) approval by FDA
  - Class II prescriptive medical device
- Hospital based and independent facilities
- Medicare reimburses only in setting of an inpatient or outpatient hospital
- Joint Commission recognizes Undersea and Hyperbaric Medicine Society accredited facilities: Virginia Mason and Southwest

4

Washington State Health Care Authority

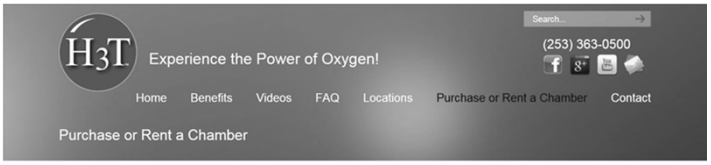
Hyperbaric Oxygen Therapy: Washington State



5

Washington State Health Care Authority

Hyperbaric Oxygen Therapy : Background



FEEDBACK

H3 Therapy Centers is your local source for buying or renting only the highest quality Hyperbaric Chambers. It has always been our goal to make hyperbaric therapy affordable to everyone. That is why we have continued to keep our rates as low as possible.

H3 Therapy Centers

Health, Healing, & Hope Through Hyperbaric Therapy

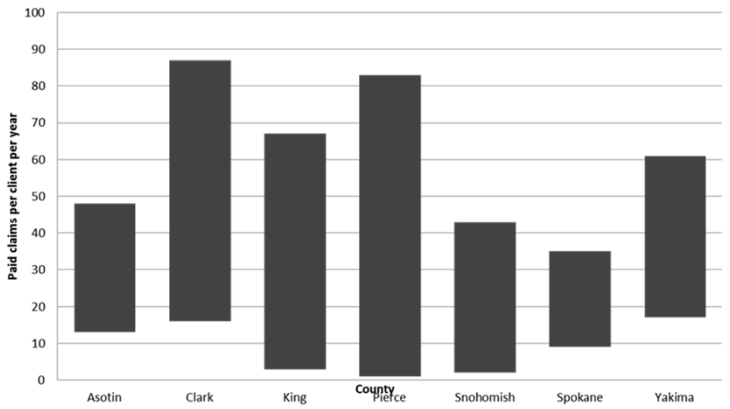
Do you need a medical condition to benefit from Hyperbaric Therapy?

~No! The use of hyperbaric chambers has not been restricted to medical doctors, health care providers and advisors. Other advocates of hyperbaric therapy include amateur, college and professional athletes in the NCAA, NFL, NBA, ABA, NHL, MLB, NASCAR, NHRA, as well as Olympians past, present and future who use hyperbaric oxygen therapy for accelerated recuperation and to increase their endurance and athletic performance.

6

Washington State Health Care Authority

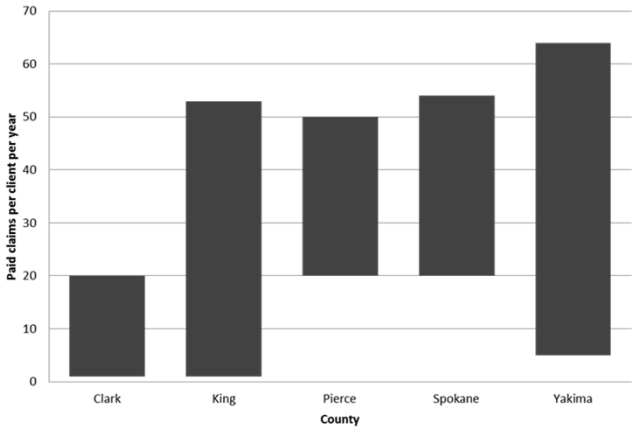
2008-2011 Paid claims per client ICD-9 250 Medicaid



7

Washington State Health Care Authority

2008-2011 Paid claims per client ICD-9 990 Medicaid



8

Washington State Health Care Authority

Medicare National Coverage Determination (20.29)

Covered Diagnoses (excluded from assessment):

- Acute carbon monoxide intoxication
- Decompression illness
- Gas embolism
- Gas gangrene
- Cyanide poisoning
- Actinomycosis, only as an adjunct to conventional therapy when the disease process is refractory to antibiotics and surgical treatment
- Progressive necrotizing infections (necrotizing fasciitis)
- Acute peripheral arterial insufficiency
- Acute traumatic peripheral ischemia. HBO therapy is a valuable adjunctive treatment to be used in combination with accepted standard therapeutic measures when loss of function, limb, or life is threatened.

Washington State Health Care Authority

Medicare National Coverage Determination (20.29)

Covered Diagnoses (included in assessment):

- Preparation and preservation of compromised skin grafts (not for primary management of wounds)
- Chronic refractory osteomyelitis, unresponsive to conventional medical and surgical management
- Crush injuries and suturing of severed limbs. As in previous conditions, HBO therapy would be an adjunctive treatment when loss of function, limb, or life is threatened

10

Washington State Health Care Authority

Medicare National Coverage Determination (20.29)

Covered Diagnoses (included in assessment)

- Osteoradionecrosis as an adjunct to conventional treatment
- Soft tissue radionecrosis as an adjunct to conventional treatment
- Diabetic wounds of the lower extremities in patients who meet the following three criteria:
  - Patient has type I or type II diabetes and has a lower extremity wound that is due to diabetes
  - Patient has a wound classified as Wagner grade III or higher; and
  - Patient has failed an adequate course of standard wound therapy

11

Washington State Health Care Authority

Current State Policy

Labor and Industries
- Prior authorization for chronic wounds

Department of Corrections
- Prior authorization for all diagnoses

Medicaid
- Prior authorization for all diagnoses

Regence
- Acute traumatic ischemia
  - Treatment review thresholds for reperfusion injury, crush injury, compartment syndrome
- Chronic refractory osteomyelitis
  - Treatment review threshold 40 treatments
- Pre and post-treatment for patients undergoing dental surgery of an irradiated jaw
- Profound anemia with exceptional blood loss: only when blood transfusion is impossible or must be delayed
- Soft tissue radiation necrosis

12

Washington State Health Care Authority

Current State Policy

Regence

- Non-healing diabetic wounds of the lower extremities as an adjunct to ongoing conventional wound care in patients who meet all of the following 3 criteria:
  - Patient has type I or type II diabetes and has a lower extremity wound that is due to diabetes
  - Wound classified as Wagner grade 3 or higher
  - Patient has no measurable signs of healing after 30 days of an adequate course of standard wound therapy including **all** of the following:
    - Assessment of vascular status and correction of any vascular problems in the affected limb if possible
    - Optimal glycemic control
    - Optimal nutritional status
    - Topical wound treatment with maintenance of a clean, moist bed of granulation tissue
    - Debridement to remove devitalized tissue, any technique
    - Pressure reduction or offloading
    - Treatment to resolve infection

13

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AMDG Workgroup Perspective

Primary Criteria Ranking

Safety = Medium

Efficacy = High

Cost = High

14

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Hyperbaric Oxygen Therapy Agency Key Questions

Safety = Medium concern

- What harms are associated with HBOT?
- Reported adverse events of otic and pulmonary barotrauma, oxygen toxicity, visual changes, seizures

15

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Hyperbaric Oxygen Therapy Agency Key Questions

Effectiveness = High concern

- Is HBOT effective in improving patient-centered outcomes for individuals with Diabetic non-healing wounds, other non-healing wounds, late radiation tissue injury, refractory osteomyelitis, brain injury, cerebral palsy, headache/migraine, multiple sclerosis, sensorineural hearing loss?
- What is the optimal frequency, dose and duration of HBOT treatment?
- What is the differential effectiveness and safety of HBOT according to factors such as age, sex, race or ethnicity, disability, comorbidities, wound or injury duration and severity and treatment setting?

16

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Hyperbaric Oxygen Therapy
Agency Key Questions

Cost = High concern

- What are the cost implications of HBOT, including the cost-effectiveness, compared to alternative treatments?

17

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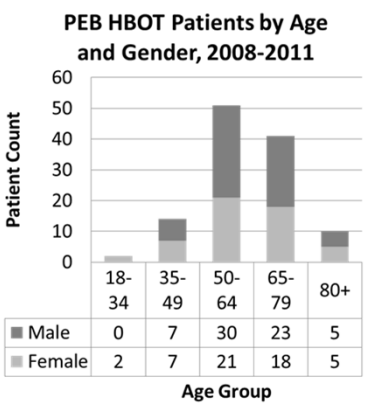
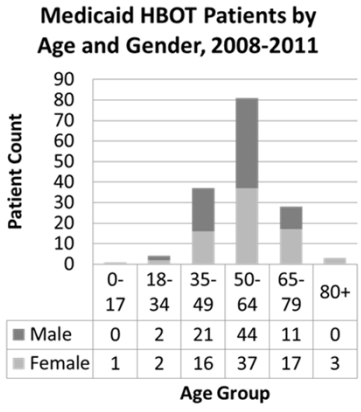
PEB[1]	2008	2009	2010	2011	4 Yr[2]	Avg Chg	
Agency Population	205K	211K	213K	213K		1.3%	
Patient Count	**28**	**34**	**32**	**40**	**118**	**12.2%**	*
Treatment Day Count	**575**	**1032**	**822**	**1037**	**3466**	**26.6%**	*
Per Patient: Avg Trtmts	20.5	30.4	25.7	25.9	29.4		
Avg Mins	1729	1973	2477	1410	2128		
Medicaid	**2008**	**2009**	**2010**	**2011**	**4 Yr[2]**	**Avg Chg**	
Agency Population	393K	417K	424K0	435K		3.5%	
Patient Count	**32**	**35**	**51**	**56**	**156**	**17.8%**	*
Treatment Day Count	**683**	**631**	**774**	**1474**	**3562**	**28.1%**	*
Per Patient: Avg Trtmts	23.6	22.5	17.6	26.8	23.0		
Avg Mins	2273	1751	1183	2920	2287		
L&I	**2008**	**2009**	**2010**	**2011**	**4 Yr[2]**	**Avg Chg**	
Agency Pop. (Claims/yr)	147K	126K	122K	121K		-6.2%	
Patient Count	**31**	**6**	**7**	**9**	**53**	**14.0%**	*
Treatment Day Count	**224**	**154**	**227**	**460**	**1065**	**45.7%**	*
Per Patient: Avg Trtmts	7.2	25.7	32.4	51.1	20.1		
Avg Mins	217	770	973	1533	602		

PEB[1]	2008	2009	2010	2011	4 Yr[2]	Avg Chg	
Agency Population	205K	211K	213K	213K		1.3%	
Amount Paid	**$309K**	**$648K**	**$364K**	**$610K**	**$1,930K**	**42.7%**	*
Per Patient Avg Paid	$11K	$19K	$11K	$15K	$16K		
Median	$6K	$16K	$5K	$4K	$6K		
Maximum	$46K	$71K	$53K	$100K	$100K		
Medicaid	**2008**	**2009**	**2010**	**2011**	**4 Yr[2]**	**Avg Chg**	
Agency Population	393K	417K	424K0	435K		3.5%	
Amount Paid	**$212K**	**$180K**	**$179K**	**$245K**	**$816K**	**-9.8%**	*
Per Patient Avg Paid	$6627	$5156	$3506	$4373	$5232		
Median	$3674	$2530	$2537	$2073	$3654		
Maximum	$22K	$28K	$19K	$28K	$28K		
L&I	**2008**	**2009**	**2010**	**2011**	**4 Yr[2]**	**Avg Chg**	
Agency Pop. (Claims/yr)	147K	126K	122K	121K		-6.2%	
Amount Paid	**$139K**	**$97K**	**$106K**	**$163K**	**$505K**	**16.6%**	*
Per Patient Avg Paid	$4479	$16K	$15K	$18K	$9526		
Median	$865	$5351	$7827	$20K	$1,638		
Maximum	$43K	$52K	$46K	$37K	$52K		

State Agency Utilization





L&I Population: 24 (Age 18-34), 16 (35-49), 12 (50-64), 66% Male

20

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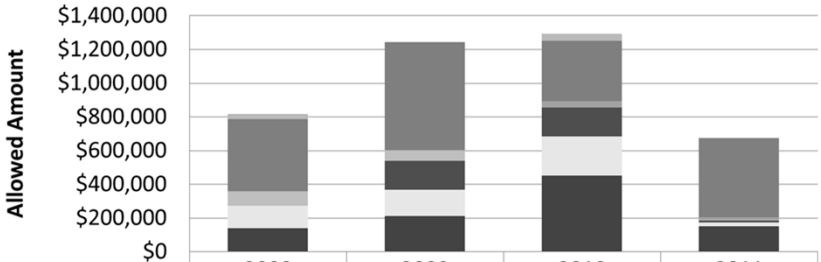
State Agency Utilization

HBOT Treatment Course Allowed Amounts

Per Patient Average Charges	PEB Primary (no Medicare)	PEB Medicare	Medicaid	L&I
Facility versus Professional charges				
Professional Services	$9382	$6649	$1,134	$3393
Facility	$18,328	$40,125	$7,156	$6134
Average Allowed Amount Patient	**$27,710**	**$46,774**	**$8290**	**$9526**

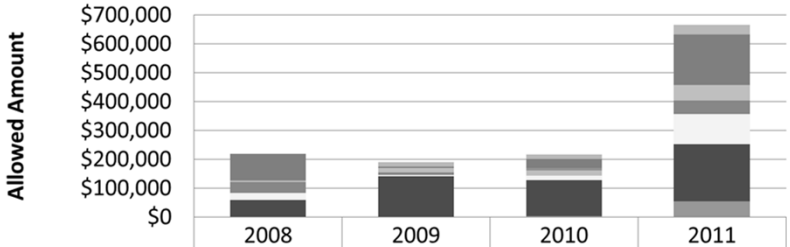
21

PEB HBOT Allowed Amounts by Diagnosis Type



	2008	2009	2010	2011
Wound	$30,659	$0	$44,878	$840
Radiation	$424,174	$640,288	$356,686	$465,830
Other	$3,829	$3,483	$36,613	$15,287
Osteomyelitis	$84,770	$61,431	$0	$4,497
Jaw necrosis	$0	$170,057	$170,753	$10,909
Graft	$131,904	$158,948	$232,516	$22,471
Diabetic wound	$141,619	$210,889	$453,375	$152,174

Medicaid HBOT Allowed Amount by Diagnosis Type



	2008	2009	2010	2011
Wound	$0	$17,221	$13,938	$32,033
Radiation	$90,314	$3,193	$32,392	$174,176
Other	$1,415	$1,404	$9,400	$883
Osteomyelitis	$5,359	$15,058	$16,637	$53,698
Jaw Necrosis	$38,664	$8,854	$971	$46,257
Graft	$24,391	$3,841	$14,324	$105,317
Diabetic Wound	$58,325	$139,844	$123,958	$198,343
Circulation	$553	$2,404	$5,119	$54,992

23

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PEB HBOT Treatment Course Variation by Diagnosis

Treatment Category	Patients	Avg. Trtmnt Days/ Patient	Trtmnt Days Range	Std. Dev. Trtmnt Days	Avg. Trtmnt Mins/ Patient	Trtmnt Minutes Range	Std. Dev. Trtmnt Mins
Radiation	47	32.7	3 - 101	20.1	2587	90 - 12030	2342
Diabetic wound	26	39.6	3 - 78	18.9	2520	90 - 8760	2108
Graft	18	21.3	1 - 61	18.7	1290	30 - 3600	1317
Jaw necrosis	6	29.2	15 - 53	15.0	2770	450 - 4620	1506
Osteomyelitis	4	37.3	14 - 62	19.8	2115	510 - 5370	2202
Wound	4	19.3	2 - 40	17.1	2168	60 - 4710	2356
Overall	**118**	**29.4**	**1 - 101**	**20.4**	**2128**	**30 - 12030**	**2084**

24

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Medicaid HBOT Treatment Course Variation by Diagnosis

Treatment Category	Patients	Avg. Trtmnt Days/ Patient	Trtmnt Days Range	Std. Dev. Trtmnt Days	Avg. Trtmnt Mins/ Patient	Trtmnt Minutes Range	Std. Dev. Trtmnt Mins
Diabetic Wound	55	27.9	1 - 93	22.2	2629	30 - 8760	2321
Radiation	38	23.3	1 - 61	17.8	2336	30 - 7020	2178
Osteomyelitis	16	22.7	2 - 63	18.1	2142	60 - 7380	2302
Graft	15	19.7	1 - 68	23.5	1544	30 - 7500	2113
Wound	15	12.6	1 - 43	13.8	1213	30 - 4830	1478
Circulation	8	25.0	1 - 53	20.6	2008	30 - 6000	1980
Jaw Necrosis	7	24.3	1 - 47	17.2	2904	30 - 5880	2242
Overall	55	**27.9**	1 - 93	22.2	**2629**	30 - 8760	2321

25

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Hyperbaric Oxygen Therapy: Risks vs. Benefits

Risks

- Lack of regulatory oversight of free standing facilities
- Assessment challenged by lack of definition of clinically meaningful outcomes and variations in practice patterns
  - No clear endpoints for treatment
  - Cost effectiveness is unknown
- Reimbursement based on utilization rather than episodes of care

Benefits

- Promotion of wound healing
- Reduced risks of major amputations
- Potential for limb and/or functional salvage

26

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Agency Considerations

- Most frequently utilized indications for HBOT are supported by a moderate quality of evidence
  - Diabetic foot ulcers
  - Late effects of radiation injury
  - Osteoradionecrosis
- Quality of evidence low:
  - HBOT use for refractory osteomyelitis may be impacted by wide array of available treatment options
  - Overlap of indications
    - Complex diabetic and radiation injury associated wounds may be treated with skin grafts or flaps
- Paucity of evidence supporting the duration, frequency and dose of HBOT for specific diagnoses

27

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Hyperbaric Oxygen Therapy: AMDG Recommendations

- **Cover with conditions:**
  - Inpatient or outpatient hospital setting
  - For treatment of:
    - Diabetic foot ulcers
      - Patient has type I or type II diabetes and has a lower extremity wound that is due to diabetes
      - Patient has a wound classified as Wagner grade III or higher; and
      - Patient has failed an adequate course of standard wound therapy
  - As an adjuvant treatment for:
    - Refractory osteomyelitis
    - Late radiation induced tissue and bone damage
    - Prevention of osteoradionecrosis following tooth extraction
  - For the prevention of loss of function or for limb salvage:
    - Compromised flaps and grafts

28

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Hyperbaric Oxygen Therapy: AMDG Recommendations

- **Not covered:**
  - Thermal burns
  - Venous, arterial and pressure ulcers
  - Migraine or cluster headaches
  - Multiple sclerosis
  - Acute and chronic sensorineural hearing loss
  - Cerebral palsy
  - Traumatic and chronic brain injuries

29

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Questions?

More Information:
http://www.hta.hca.wa.gov/hbot.html

30

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Hyperbaric Oxygen Therapy (HBOT) for Tissue Damage, Including Wound Care and Treatment of Central Nervous System (CNS) Conditions

Karen Crotty, PhD, MPH

Hayes

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Hayes

2

Presentation Overview

- Introduction
- Methodology
- Key Question 1
  - Summary of Findings
- Key Questions 1a, 2, 3, and 4
  - Summary of Findings
- Practice Guidelines and Selected Payer Policies
- Gaps in the Evidence

Hayes

3

Key Questions

1. Is HBOT effective in improving patient-centered outcomes for individuals with the following conditions?
   - Diabetic nonhealing wounds, including foot ulcers
   - Other nonhealing wounds, including ulcers, flaps and grafts, thermal burns, and surgical wounds
   - Refractory osteomyelitis
   - Late radiation tissue injury (LRTI)
   - Brain injury, including traumatic brain injury (TBI) and other brain injuries but excluding stroke
   - Cerebral palsy
   - Multiple sclerosis (MS)
   - Headache/migraine
   - Sensorineural hearing loss

1a. What is the optimal frequency, dose, and duration of HBOT treatment?

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4

Key Questions (cont.)

2. What harms are associated with HBOT?
3. What is the differential effectiveness and safety of HBOT according to factors such as age, sex, race or ethnicity, disability, comorbidities, wound or injury duration and severity, and treatment setting?
4. What are the cost implications of HBOT, including the cost-effectiveness compared with alternative treatments?

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5

Methods

- Topic scoping revealed a very large body of evidence
- Approach:
  - Systematic search for systematic reviews (SRs) and health technology assessments (HTAs)
  - Search for primary data from randomized controlled trials (RCTs) published after the most current selected systematic review for each indication.
  - All harms-specific studies published in the last 10 years.

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6

Methods: Main Evidence and Information Sources

- SRs, HTAs, primary and harms data:
  - MEDLINE, Cochrane, York University CRD, Embase, manual search of bibliographies
- Cost studies – in addition to the above:
  - The National Health Service Economic Evaluation Database (NHS-CRD)
- Guidelines – in addition to the above:
  - National Guideline Clearing House
- Common coverage policies:
  - CMS, Aetna, Regence BCBS, GroupHealth

Hayes

7

SR/HTA Evidence Selection

- Title and abstract review followed by a full text review using predefined inclusion/exclusion criteria
- Inclusion criteria:
  - SRs and HTAs investigating the effectiveness, safety, or cost associated with HBOT for the indications under investigation
  - English language
  - 2002 to June 2012

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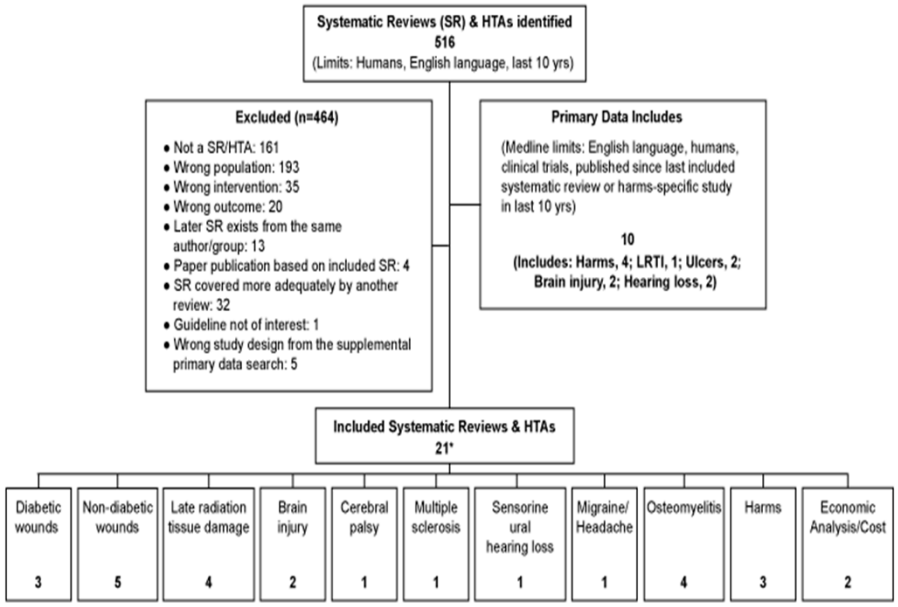
8

Figure 1. Systematic Identification and Selection of Evidence



*Some reviews covered more than 1 indication

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9

Quality Assessment

- Three main steps:
  1. Systematic review appraisal
  2. Quality assessment of individual studies
  3. Evaluation of body of evidence for each outcome

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10

SR/HTA Appraisal

- Assessment of Multiple Systematic Reviews (AMSTAR) tool
  - Useful for assessing the quality of meta-analysis
  - Allowed us to judge the reliability of selected systematic reviews and identify areas where additional information might be needed

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11

Quality Assessment: Individual Studies

- *Good-Fair-Poor-Very Poor*
- Study design, execution, and analysis (checklist)
- Internal validity (minimization of bias)
- *Are the study findings valid?*

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12

Quality Assessment:
Evaluation of the Body of Evidence (Each Outcome)

- *High-Moderate-Low-Very Low*
- Considerations
  - Study design and weaknesses (risk of bias)
  - Applicability to PICO
  - Quantity/Precision of the data
  - Consistency of study findings across studies
  - Publication bias
- *How confident are we that this evidence answers the Key Questions?*

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13

Quality of the Body of Evidence

High
- Reliable evidence reflecting the true effect
- Unlikely to change with future studies

Moderate
- Reasonable confidence that the results represent the true direction of effect
- The effect estimate might change with future studies

Low
- Little confidence due to poor quality and/or mixed results and/or a paucity of studies
- Future studies are likely to change the estimates and possibly the direction

Very Low
- No confidence in any result found (e.g., paucity of data)
- Data is such that we cannot make a statement on the findings

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14

KQ1. Is HBOT effective in improving patient-centered outcomes for individuals with the following conditions?

- Diabetic nonhealing wounds, including foot ulcers
- Other nonhealing wounds, including ulcers, flaps and grafts, thermal burns, and surgical wounds
- Refractory osteomyelitis
- LRTI
- Brain injury, including TBI and other brain injuries but excluding stroke
- Cerebral palsy
- MS
- Headache/migraine
- Sensorineural hearing loss

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15

Key Question 1

- 16 SRs (133 primary data studies)
- Additional 5 primary data studies (published subsequent to the selected reviews)
- 7225 total participants
- 61 RCTs
- 4 nonrandomized controlled trials
- 8 pre-post studies (7 uncontrolled, 1 with historical controls)
- 64 other observational studies, including prospective and retrospective cohorts as well as case series

Hayes

16

Evidence-Based Conclusions

Indications for Which There Is Moderate-Quality Evidence of the Effectiveness of HBOT

- **Diabetic foot ulcers**: Wound healing and limb salvage
- **LRTI**: Head and neck, anus, and rectum
- **ORN**: Following tooth extraction in a previously irradiated area
- **TBI**: Reduces risk of dying but does not improve functional outcomes

Indications for Which There Is Low-Quality Evidence of the Effectiveness of HBOT

- **Nondiabetic ulcers, flaps and grafts, crush injuries, and surgical reconstruction** (without grafts or flaps): Small quantity of evidence
- **Refractory osteomyelitis**: Low-quality evidence
- **Acute migraine relief**: Small sample size
- **Sensorineural hearing loss (acute phase):** Mixed evidence

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17

Evidence-Based Conclusions (cont.)

Indications for Which There Is Moderate-Quality Evidence of <u>No</u> Effectiveness of HBOT

- **MS** (no meaningful benefit; no RCTs found on this topic post 1990)
- **Chronic sensorineural hearing loss**

Indications for Which There Is Insufficient Evidence to Assess Effectiveness

- **Thermal burns**
- **Cerebral palsy**
- **Brain injuries other than TBI**
- **Cluster headaches**

Primarily due to mixed results or an overall paucity of studies.

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18

Indications for Which There Is Moderate-Quality Evidence of the Effectiveness of HBOT

- **Diabetic nonhealing wounds, including foot ulcers**
- Other nonhealing wounds, including ulcers, flaps and grafts, thermal burns, and surgical wounds
- Refractory osteomyelitis
- **LRTI**
- Brain injury, including **TBI** and other non-TBI brain injuries but excluding stroke
- Cerebral palsy
- MS
- Headache/migraine
- Sensorineural hearing loss

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KQ1. Diabetic Nonhealing Wounds

Outcome	Summary of Key Findings	Direction	QOE
Incidence of complete healing 12 studies; 1 good, 4 fair, 5 poor, 2 very poor (n=582)	SR (4 RCTS; 1 very poor not included in pool) **3 pooled RCTs (n=140; 1 good, 1 fair, 1 poor)** 6 wks: RR=5.2 (CI, 1.3-22) NNT=8; absolute risk difference 12.2% 12 mos: RR=9.53 (NS) (I^2=85%) 12 mos individual study results**:** HBOT 52%, Controls 29% (*P*=0.03) (good RCT); HBOT 5/8, Controls 0/8 (*P*=0.026) (fair RCT) **2 other SRs** (8 observational studies): • 1 fair cohort study found sig more complete healing at 7 wks f/u in favor of HBOT • 1 fair cohort study found no diff between grps • 6 poor/very poor studies reported positive findings	Benefit at 6 wks and 1 yr	Moderate
F/u: 6 wks to 3 yrs; Dose: 2.0-3.0 ATA, 45-120 mins; # HBOT sessions: 20-60 once or twice daily mostly 5 or 6 times per week; lesion severity varied from early diabetic foot to Wagner grade 4			

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KQ1. Diabetic Nonhealing Wounds (cont.)

Outcome	Summary of Key Findings	Direction	QOE
Amputation 7 studies;1 good, 3 fair, 3 poor, (n=462)	**5 pooled RCTs (n=309)** At final f/u RR=0.36 (CI, 0.11-1.18) (NS); sig on removal of 1 study which excluded high-risk pts (*P*=0.009) **Observational studies:** 2 fair quality • 14% vs 31% in favor of HBOT (*P*=0.012) • 12% vs 33% (NS)	Benefit	Moderate
F/u: At discharge (92 wks) to 3 yrs; Dose: 2.2-3.0 ATA, 90 mins ; # HBOT sessions: 4-60 once or twice daily 5 or 6 times per week in most cases			

KQ1. Late Radiation Tissue Injury (LRTI)

Outcome	Summary of Key Findings	Direction	QOE
Resolution of tissue damage or necrosis 18 studies, 5 RCTs, 13 CS	**4 pooled RCTs (2 good, 1 fair, 1 unclear):** 36% vs 28% in favor of HBOT (n=325) (I^2=82%) (no estimate of effect) **Hemorrhagic cystitis (1 fair RCT)**: 75% in HBOT grp at 6 mos, 50% at 12 mos, 45% at 18 mos; NS difference between HBOT and intravesical hyaluronic acid instillation (n=36) **Soft tissue radionecrosis (13 CS)**: 50%-100% complete or partial healing (n=168) (complete or partial healing)	Benefit	Moderate
Pooled data: F/u: ≤3 mos; Dose: 2.0-2.4 ATA, 90-100 mins; # HBOT sessions: 30-40; Time frame from radiation tx to HBOT: NR; 2 studies specified the presence of radiation damage for ≥3 mos; Radiation dose: Not always specified; commonly >30 or >60 Gy **Hemorrhagic cystitis:** F/u, 6,12, and 18 mos; dose, 2.5 ATA, 60 mins; # HBOT sessions ≥28 Soft tissue radionecrosis: Poor reporting; Time frame from radiation tx to HBOT: NR; Radiation dose: 45-70 Gy			

KQ1. Late Radiation Tissue Injury (cont.)

Outcome	Summary of Findings	Direction	QOE
Prevention of ORN after tooth extraction 9 studies; 1 fair, 7 poor, 1 unclear (n=713)	9 pooled observational and trial studies Incidence rate 4% vs 7% (overall rate) in favor of HBOT (1 fair, 7 poor, 1 unclear; n=713) Incidence rate at 6 mos: RR=0.18 (*P*=0.005); absolute rates 5.4% vs 29.9% in favor of HBOT (RCT unclear quality; n=74)	Benefit	Moderate
F/u: 2.5-42 mos; Dose: 2.4 ATA, 90 mins; # HBOT sessions: 30 where reported; Time frame from radiation tx to HBOT: >6mos and <15 yrs where reported; Radiation dose: >60 Gy where reported			
Complete mucosal cover and establishment of bony continuity for ORN 3 studies; 1 fair, 2 unclear (n=246)	Pooled data from 3 RCTs (n=246) RR=1.3 (CI, 1.1-1.6) NNT=5 Absolute rates 84% vs 65% in favor of HBOT	Benefit	Moderate
F/u: 6-18 mos where reported ; Dose: 2.4 ATA, 90 mins; # HBOT sessions:30; Time frame from radiation tx to HBOT: >6mos and <15 yrs in 1 study; presence of ORN for 2 mos in another; Radiation dose: >60 Gy where reported			

KQ1. Traumatic Brain Injury (TBI)

Outcome	Summary of Findings	Direction	QOE
Mortality 4 fair (n=387)	**4 pooled RCTs** (all fair) RR=0.69 (CI, 0.54-0.88) (I^2=0%) NNT=7 (CI, 4-22) Absolute risk difference 15% Absolute rates 28% vs 41%	Benefit (i.e., reduced risk of death but w/ no evidence of improved function)	Moderate
Functional outcomes among pts w/ TBI 4 studies; 3 fair, 1 poor (n=382)	**4 pooled RCTs** (3 fair ,1 poor) Unfavorable functional outcome^ at final assessment: RR=0.51; 95% CI, 0.25-1.08 (NS) (I^2=81%) **1-yr f/u (1 fair RCT; n=168)** Unfavorable functional outcome RR=1.02; 95% CI, 0.77-1.36 (NS)	No benefit	Low due to imprecision and inconsistency
F/u: 10 days to 1 yr; Time frame: Enrollment at 6-hrs to 5-days postinjury; Dose: 1.5-2.5 ATA, 40-80 mins; # HBOT sessions: 10-40; ^ severe disability, vegetative state, or death			

Indications for Which There Is Low-Quality Evidence of the Effectiveness of HBOT

- Diabetic nonhealing wounds, including foot ulcers
- **Other nonhealing wounds, including ulcers, flaps and grafts,** thermal burns, and surgical wounds
- **Refractory osteomyelitis**
- LRTI
- Brain injury, including TBI and other brain injuries but excluding stroke
- Cerebral palsy
- MS
- Headache/migraine
- **Sensorineural hearing loss** (**acute** and chronic)

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25

KQ1. Nondiabetic Nonhealing Wounds

Wound Type	Summary of Findings	Direction	QOE
Venous, arterial, and pressure ulcers 3 studies; 2 fair, 1 very poor (n=81)	**Chronic nonhealing wounds:** Wound area reduction 30-days: HBOT 59%↓ vs controls 26%↑ (*P*=0.001) (fair RCT; n=30) **Venous wounds:** Wound area reduction 6 wks: 35.7% vs 2.7% in favor of HBOT (MD 33%; 95% CI, 19-47) 18 wks: 55.8% vs 29.6% (MD 29.6%; CI, –23 to 82) (NS) (fair RCT; n=16) **Leg ulcers:** 80% complete wound healing (case series)	Short-term benefit	Low due to insufficient evidence
F/u: 30 days to 18 wks; Dose: 2-2.5 ATA, 90 mins; # HBOT sessions: 20-30			
Compromised grafts and flaps 7 studies; 1 unknown, 2 poor, 4 very poor (n=425)	**Graft survival:** 64% HBOT vs 17% usual care at 7 days (RR=3.5; CI,1.4-9.1; NNT=2) (poor RCT); 4 case series reported 50%-100% graft or flap take following HBOT **Graft wound healing:** HBOT 11% delayed healing vs 55% in controls (*P*=0.001) (RCT unknown quality) **Flap survival:** HBOT was no better than dexamethasone (89% vs 78%) or heparin at 7 days (89% vs 73%) (poor RCT)	Benefit vs no tx	Low due to high or unknown risk of bias
Time frame and f/u: Immediately pre- and/or postsurgery ; Dose: 2 ATA, 120 mins (where reported); # HBOT sessions: 6-20			

Hayes

26

KQ1. Refractory Osteomyelitis

Outcome	Summary of Findings	Direction	QOE
Resolution/ cure 23 studies; 1 poor, 21 very poor (n=478)	87% in favor of HBOT as an adjunct to standard care (range 37%-100%) (21 case series; n=450) 79% (11of 14) in HBOT grp, 93% (13 of 14) in control grp (NS) (poor nonrandomized controlled trial; n=28)	Benefit	Low due to high risk of bias
Defined broadly as 6 mos of infection coupled with failed response to antibiotics and/or surgical intervention; F/u: 3-84 mos; Dose: poorly reported; # HBOT sessions: 17-50			
I**nfection relapse rate** 2 studies; 1 fair, 1 poor (n=60)	0% vs 33.3% in favor of HBOT (*P*=0.024) (fair nonrandomized controlled trial; n=32) 14% (2 of 14) in HBOT grp vs 7% (1 of 14) in control group (NS) (poor nonrandomized controlled trial; n=28)	Mixed w/ more confidence in the study demonstrating a benefit	Low due to high risk of bias and insufficient evidence
F/u: 41 mos; Dose: 2-3 ATA, 90-120 mins; # HBOT sessions: Poorly reported			

Hayes

27

KQ1. Migraine

Outcome	Summary of Findings	Direction	QOE
Resolution or sig relief **3 fair (n=43)**	**Pooled data from 3 fair RCTs (n=43)** **RR=5.97 (CI, 1.46-24.38)** **NNT=2 (CI, 1-2)**	**Benefit**	**Low due to small sample size**
F/u: Immediately posttx; Dose: 2 ATA, 40-45			
Reduction in nausea/vomiting 1 fair (n=40)	RR=0.84 (CI, 0.64-1.11) (NS)	No benefit	Very low due to insufficient evidence
Migraine pain intensity 1 fair (n=8)	MD 2.8 (CI, –4.69 to 10.29) (NS)	No benefit	Very low due to insufficient evidence
Frequency of migraines 1 fair (n=40)	MD during wk 1: –0.13 (NS) MD during wk 4: –0.25) (NS) MD during wk 8: –0.75 (NS)	No benefit	Very low due to insufficient evidence
Need for rescue medication 1 fair (n=40)	RR=1.27 (CI, 0.68-2.38) (NS)	No benefit	Very low due to insufficient evidence

Hayes

28

KQ1. Acute Sensorineural Hearing Loss

Outcome	Summary of Findings	Direction	QOE
Hearing improvement/ recovery 8 studies; 4 poor, 4 fair (n=439)	**Benefit** **Pooled data from 2 RCTs** (1 fair, 1 poor; n=114) % pts w/ >25% return of hearing: RR=1.3 (CI, 1.05-1.84); NNT=5 (CI, 3-20); absolute risk diff 22% **Pooled data from 2 RCTs** (1 fair, 1 poor; n=92) Mean improvement: MD 15 dB favoring HBOT (CI, 1.5-29.8) Improvement in PTA from baseline to posttx (1 fair RCT; n=50); WMD 37% in favor of HBOT (CI, 22%-53%); absolute values 61% vs 24% **No Benefit** **Pooled data from 2 RCTs** (1 fair, 1 poor; n=114) % pts w/ >50% return of hearing: RR=1.53 (CI, 0.85-2.78) (NS) % pts w/ complete (>50 dB) or moderate (10-50 dB) recovery (1 fair RCT; n=57) 79% vs 71% (NS) Absolute improvement in PTA >20 dB: RR=3.0 (CI, 0.14-65.9) (NS) (fair-quality RCT; n=20)	Mixed	Low due to inconsistency
F/u: Posttx; Dose: 1.5-2.5 ATA, 45-90 mins; # HBOT sessions: 10-20; Time frame from onset to tx: 2-14 days; Severity of hearing loss: Varied widely from mild to severe and NR in 4 studies			

Hayes

29

Indications for Which There Is Moderate-Quality Evidence of No Effectiveness of HBOT

- Diabetic nonhealing wounds, including foot ulcers
- Other nonhealing wounds, including ulcers, flaps and grafts, thermal burns, and surgical wounds
- Refractory osteomyelitis
- LRTI
- Brain injury, including TBI and other brain injuries but excluding stroke
- Cerebral palsy
- **MS**
- Headache/migraine
- **Sensorineural hearing loss** (acute and **chronic**)

Hayes

30

KQ1. Multiple Sclerosis

Outcome	Summary of Findings	Direction	QOE
Reduction in Expanded Disability Status Scale (EDSS) 5 studies; 2 good, 3 fair (n=271)	Mean change in EDSS immediately posttx (pooled data from 5 RCTs; n=271): 0.07 (CI, –0.23 to 0.09) (NS) Mean change in EDSS 6-mos posttx (pooled data from 3 RCTs; n=163): –0.22 (CI, –0.54 to 0.09) (NS) Mean change in EDSS at 12-mos posttx (pooled data from 2 RCTs; n=81): –0.85 (CI, –1.28 to –0.42 (1-point change considered clinically meaningful)	No meaningful benefit	Moderate
F/u: Immediately posttx-12 mos; Dose: 1.75-2.5 ATA, 90 mins; # HBOT sessions: 20-75; Mean EDSS at BL: <7.5			
Prevention of exacerbation 5 studies; 1 good, 4 fair (n=392)	Odds of an exacerbation at 1-mo posttx: OR=0.31 (CI, 0.01-7.8) (NS) (1 fair RCT; n=117) Odds of an exacerbation at 6-mos posttx (2 pooled fair RCTs; n=122): OR=0.74 (CI, 0.25-2.22 (NS) Odds of an exacerbation at 12-mos posttx (2 pooled fair RCTs; n=153): OR=0.38 (CI, 0.04-3.22) (NS)	No benefit	Moderate
F/u: 1-12 mos; Dose: 1.75-2.5 ATA, 90 mins; # HBOT sessions: 20-27; Mean EDSS at BL: <8			

Hayes

31

KQ1. Chronic Sensorineural Hearing Loss

Outcome	Summary of Findings	Direction	QOE
Hearing improvement or recovery 2 fair (n=81)	% pts w/ improved hearing (1 fair RCT; n=44); RR=0.64 (CI, 0.30-1.33) (NS) Absolute values 7 vs 11 pts Mean hearing improvement (1 fair RCT; n=37); MD 1.4 dB (CI, –3.2 to 6.0) (NS)	No benefit	Moderate
F/u: 4 wks where reported; Dose: 1.5-2.5 ATA, 45-60 mins; # HBOT sessions: 10-15; Time frame from onset to tx: 14 days to 1 yr; Severity of hearing loss: NR			

Hayes

32

Indications for Which There Is Insufficient Evidence to Assess Effectiveness

- Diabetic nonhealing wounds, including foot ulcers
- Other nonhealing wounds, including ulcers, flaps and grafts, surgical wounds (without flaps and grafts), **crush injuries, thermal burns**
- Refractory osteomyelitis
- LRTI
- Brain injury, including TBI and **other non-TBI brain injuries** but excluding stroke
- **Cerebral palsy**
- MS
- **Headache**/migraine
- Sensorineural hearing loss (acute and chronic)

Hayes

33

Indications for Which There Is Insufficient Evidence to Assess Effectiveness

Wound Type	# Studies	Direction	QOE
Surgical reconstruction (w/o grafts or flaps)	2 poor case series (n=84)	Benefit	Low due to insufficient evidence
Crush injuries	1 fair RCT (n=36)	Benefit for healing	Very low due to insufficient evidence
Thermal burns	2 fair RCTs (n=141)	Mixed	Very low due to inconsistency and insufficient evidence
Non-TBI brain injury	6 poor or very poor (n=386) (pre-post and cohorts)	Benefit	Very low due to insufficient evidence
Cerebral palsy	3 fair (1 RCT, 2 pre-post; n=143), 4 poor (2 RCTs, 2 observational; n=417)	Mixed	Very low due to high risk of bias, inconsistency, and insufficient evidence
Cluster headaches	1 poor RCT (n=13), 1 fair (n=16)	No benefit	Very low due to insufficient evidence

Hayes

34

1a. What is the optimal frequency, dose, and duration of HBOT treatment?

- Several SRs planned to examine the optimal frequency, duration, and dose of treatment but found very little data in the published research
- No study looked at the duration of treatment sessions.
- 3 SRs conducted some form of subgroup analyses relevant to the question of frequency and dose.
  - The evidence is insufficient due to the paucity of studies, and mixed results or a high risk of bias in studies where data were available.

Hayes

35

KQ2. What harms are associated with HBOT?

- 15 SRs and 4 primary data studies provided data on safety
- Harms are generally mild and self-limiting and include:
  - Barotraumas
  - Temporary visual disturbances
  - Claustrophobia
  - More rarely, oxygen toxicity

Hayes

36

Notable Indication-Specific Harms Found in the Literature Include:

Indications	Harms
LRTI	3 studies reported harms Ear pain: 16% (n=150); transient myopia (3% in 1 study, 8% in another) and confinement anxiety (1.7%).
TBI	Pooled data, 2 trials (n=228) Severe pulmonary complications: 13% HBOT vs none in controls (RR=15.57; 95% CI, 2.11-114.72).
Cerebral palsy	4 studies reported harms Ear problems: 47% HBOT vs 22% controls (n=111) 12% seizure rate; ear problems, 35% pts (n=26 poor quality) 8% stopped tx due to adverse events (n=50) 1 seizure, observational study (n=230)
MS	Pooled data, 4 trials Temporary deterioration in visual acuity: 77 pts (55%) in HBOT grps vs 3 pts (2.3%) in sham grps (OR=24.87; 95% CI, 1.44-428.5; NNT=1; 95% CI, 1-2)

Hayes

37

KQ3. What is the differential effectiveness and safety of HBOT according to factors such as age, sex, race or ethnicity, disability, comorbidities, wound or injury duration and severity, and treatment setting?

- 6 SRs and 4 additional primary data studies
- No relevant data
  - Sex, race, ethnicity, disability, wound duration, or treatment setting
- Mixed data
  - Age
  - Severity of hearing loss
- Low-quality evidence
  - Radiation dose
  - Transcutaneous oxygen measurement (TCOM)

Hayes

38

KQ3. Differential Effectiveness and Safety of HBOT

Factor	Differential Effectiveness	Direction	QOE
Age 1 RCTs, 1 case series	Sensorineural hearing loss: No sig difference in hearing recovery among pts age <50 vs ≥50 yrs (*P*>0.05) (fair RCT; n=57) Sig improvement in hearing recovery among pts >50 yrs (very-poor case series; n=19)	Mixed	Insufficient
Degree of hearing loss 3 RCTs	Pooled data from 2 RCTs (1 fair, 1 poor) Severe hearing loss (n=14): MD 37.7 dB (95% CI, 22.9-52.5); Mild hearing loss (n=19): MD 0.2 (95% CI, –10 to 10.4) Severity of hearing loss not related to either 25% or 50% improvement in hearing following HBOT (poor RCT)	Mixed	Insufficient

KQ3. Differential Effectiveness and Safety of HBOT

Factor	Differential Effectiveness	Direction	QOE
Radiation dose 1 RCT, 8 observational	ORN following post-irradiation tooth extraction was more likely-at >60 vs < 60 Gy	Higher dose greater benefit	Low
TCOM under hyperbaric conditions 1 fair, 4 poor observational	Predictor of HBOT response: Good	TCOM predicts response to HBOT	Low
TCOM at sea level 1 fair RCT 2 poor observational	Predictor of HBOT response: Mixed evidence when TCOM is performed in normal air or w/ 100% oxygen breathed at sea level	Mixed	Very low

KQ4. What are the cost implications of HBOT, including the cost-effectiveness compared with alternative treatments?

- Two good-quality SRs, including 11 studies, provided low-quality evidence on the cost-effectiveness of HBOT for:
  - Diabetic wounds
  - Nondiabetic nonhealing wounds
  - ORN
  - Thermal burns
- All found HBOT to be cost effective or cost saving.
- All were severely limited by sparse cost data and/or the unreliable efficacy estimates used to make model assumptions.
- Only one model was found to be robust during sensitivity analysis.
- Overall, current data are insufficient to determine the most cost-effective uses of HBOT.

Hayes

41

KQ4. Cost-Effectiveness of HBOT by Indication

Indication	Cost-Effectiveness	Direction	QOE
Diabetic wounds	5 studies suggested that HBOT is cost effective under the assumptions of the various models but only 1 model was robust during sensitivity analysis 2007 Canadian-based decision tree analysis: Adjunctive HBOT was dominant over standard care alone: • 3.64 QALYs gained among the HBOT grp vs 3.01 among controls • 12-yr pt cost CAD 40,695 (USD 40,438) for the HBOT grp and CAD 49,786 (USD 49,471) for controls (dollar values using 2013 adjusted rate)	Cost effective	Low

Hayes

42

Practice Guidelines

- Of 27 reviewed,14 were included as generally good-quality guidelines
  - 2 covered multiple indications
  - 2 specific to diabetic foot ulcers
  - 4 specific to pressure ulcers
  - 1 on lower-extremity amputations
  - 1 on nonhealing ischemic wounds
  - 1 on ORN
  - 1 on cerebral palsy
  - 1 sensorineural hearing loss
  - 1 on the use of HBOT for critically ill patients

Hayes

43

Practice Guidelines

Indication	Guidelines	Consistent with this report
Wounds (cross-cutting) (2 guidelines)	*European Committee for Hyperbaric Medicine (ECHM) and the European Tissue Repair Society (ETRS) (2007)* (good quality) *Wound Healing Society (2006)* (fair quality) – U.S. • Recommended only for nonhealing wounds where standard care has not been effective • Evidence pertaining to diabetic wounds stronger than for other nonhealing wounds.	Yes
Diabetic foot ulcers (2 guidelines)	*NICE (2011)* (good quality) – UK • Recommended against HBOT for inpts w/ diabetic foot ulcers unless as part of a clinical trial. • Despite recognition of moderate-level evidence. *Wound Healing Society (2006)* (fair quality) – U.S. • Recommended for diabetic foot ulcers.	No for 2011 NICE report Yes for 2006 Wound Healing Society

Hayes

44

Practice Guidelines (cont.)

Indication	Guidelines	Consistent with this report
Pressure ulcers (4 guidelines)	*Institute for Clinical Systems Improvement (ICSI) (2012)* (fair quality)*; European Pressure Ulcer Advisory Panel and National Pressure Ulcer Advisory Panel (2009*) (good quality); *Association for the Advancement of Wound Care (2010)* (good quality) • Recommended against the use of HBOT as adjunct tx in the management of pressure ulcers because of insufficient evidence. *Registered Nurses' Association of Ontario (good quality)* • Recommended that HBOT be considered for the management of pressure ulcers, basing their recommendation on expert opinion and consensus.	Yes (in 3 of 4)
Lower extremity amputations (2 guidelines)	*Department of Veterans Affairs (VA)/Department of Defense (DOD) (2007)* (fair quality) • Recommended HBOT as an adjunct tx for impaired postoperative wound healing.	Yes

45

Practice Guidelines (cont.)

Indication	Guidelines	Consistent with this report
Nonhealing ischemic ulcers (1 guideline)	*The Wound, Ostomy and Continence Nurses Society (2008)* (fair quality) • HBOT be considered for lower extremity arterial ulcers (despite a lack of evidence).	No
LRTI (ORN) (1 guideline)	*The Dutch Head and Neck Oncology Cooperative Group (2007)* (fair quality) • HBOT for tx of ORN of the mandible.	Yes
Cerebral Palsy (1 guideline)	*Canadian agency AETMIS* (fair quality) • HBOT not recommended for cerebral palsy.	Yes
Hearing loss (1 guideline)	*American Academy of Otolaryngology – Head and Neck Surgery (2012)* (very good quality) • HBOT is an "option" for pts presenting w/in 3 mos of onset. The panel reasoned that the level of evidence, albeit modest and imprecise, was sufficient to promote greater awareness of HBOT.	No

46

Selected Payer Policies

- Examined the polices of CMS, Aetna, Regence BCBS, and GroupHealth.
- Generally consistent with the findings of this report with the notable exception of refractory osteomyelitis.
- Conditions that this report found to have at least moderate-quality evidence supporting HBOT are covered by most, if not all, payers.
- Conditions with moderate-quality evidence showing no benefit of HBOT are not covered by the selected payers.
- All 4 payers cover HBOT for refractory osteomyelitis despite the low overall quality grade assigned to the evidence in this report (may reflect the difficulty in gathering good quality evidence on this condition).
- Payers are split over those conditions where the evidence conflicts, is weak, or insufficient. For example:
  - 3 of 4 cover crush injuries, compromised skin grafts, and peripheral arterial insufficiency.
  - None cover headaches/migraine, thermal burns, brain injury, cerebral palsy, or MS.
  - Aetna covers sensorineural hearing loss.

Hayes

47

Evidence-Based Conclusions

Indications for Which There Is Moderate-Quality Evidence of the Effectiveness of HBOT

- **Diabetic foot ulcers**: Wound healing and limb salvage
- **LRTI**: Head and neck, anus, and rectum
- **ORN**: Following tooth extraction in a previously irradiated area
- **TBI**: Reduces risk of dying but does not improve functional outcomes

Indications for Which There Is Low-Quality Evidence of the Effectiveness of HBOT

- **Nondiabetic ulcers, flaps and grafts, crush injuries, and surgical reconstruction** (without grafts or flaps): Small quantity of evidence
- **Refractory osteomyelitis**: Low-quality evidence
- **Acute migraine relief**: Small sample size
- **Sensorineural hearing loss (acute phase)**: Mixed evidence

Hayes

48

Evidence-Based Conclusions (cont.)

Indications for Which There Is Moderate-Quality Evidence of No Effectiveness of HBOT

- Little benefit of HBOT for the treatment of **MS** (no RCTs found on this topic post 1990)
- No benefit among patients with **chronic sensorineural hearing loss**

Indications for Which There Is Insufficient or Inconsistent Evidence to Assess Effectiveness

- Insufficient evidence, primarily due to mixed results or an overall paucity of studies, for the treatment of:
  - **Thermal burns**
  - **Cerebral palsy**
  - **Brain injuries other than TBI**
  - **Cluster headaches**

Hayes

49

Gaps in the Evidence

- Future work needs to include:
  - Methodologically rigorous studies, adequately powered, free from the risk of publication bias, and generalizable to the population of patients under review.
  - Specifically address frequency, duration, and dose, as well as differential effectiveness, across each indication and for a variety of subpopulations.
  - Robust models from reliable cost and effectiveness data.

Hayes

50

Thank you

KQ1. Nondiabetic Nonhealing Wounds (cont.)

Wound Type	Summary of Findings	Direction	QOE
Surgical reconstruction (w/o grafts or flaps) 2 poor (n=84)	Improved healing: 89% vs 73% in favor of HBOT (*P*<0.05) (poor cohort) Infection and breakdown: HBOT 17%, control 78% (*P*<0.01) (poor cohort)	Benefit	Low due to insufficient evidence
F/u: NR; Dose: 2 ATA, 90 mins (where reported); # HBOT sessions: 20; Time frame: Postoperative administration			
Crush injuries 1 fair (n=36)	Complete healing: 94% vs 56% in favor of HBOT (RR=1.7; 95% CI, 1.11-2.61; NNT=3) (fair RCT) Mean time to healing, amputation rate, and hospital stay: NS difference between grps	Benefit for healing	Very low due to insufficient evidence
Dose: 2.5 ATA, 90 mins over 6 days; poor reporting on other details			

KQ1. Nondiabetic Nonhealing Wounds (cont.)

Wound Type	Summary of Findings	Direction	QOE
Thermal burns 2 fair (n=141)	No differences in length of hospital stay, mortality (11% in each grp), or # surgeries in HBOT compared w/ control grps (fair RCT; n=125) Significantly better time to healing in HBOT grp (19.7 days) compared w/ control grp (43.8 days) (*P*<0.001) (fair RCT; n=16)	Mixed	Very low due to inconsistency
F/u: NR; Dose: 2 ATA, 90 mins; # HBOT sessions: 10 to time of healing; Time frame: Admitted w/in 24 hrs of injury			
Acute traumatic peripheral ischemia 1 very poor (n=23)	Improved wound recovery and complete healing following HBOT (no control and no details provided)	Benefit	Very low due to insufficient evidence
Poor reporting			

Hayes

KQ1. Non-TBI Brain Injury

Outcome	Summary of Findings	Direction	QOE
Mortality	7% mortality following HBOT, no controls (poor pre-post study; n=136)	Insufficient evidence	Very low due to insufficient evidence
Dose: 2.5 ATA, 90 mins, poor reporting of other clinical details			
Functional outcomes	5%-10% improvement in memory (poor observational study; n=32) Significantly better cognitive performance compared w/ historical controls (poor pre-post-study; baseline differences created bias in favor of HBOT; n=126)	Benefit	Very low due to insufficient evidence
Poor reporting of clinical details			
Symptoms	Positive results (38% to 68% cure rate) but serious methodological flaws (1 poor, 2 very poor; n=92)	Benefit	Very low due to insufficient evidence
Poor reporting of clinical details			

Hayes

KQ1. Cerebral Palsy

Outcome	Summary of Findings	Direction	QOE
Motor function 3 fair (n=143)	Trial data (1 RCT; n=111) NS difference between grps immediately posttx or at 6 mos; both grps improved significantly (GMFM 3.4 vs 3.1 at 6 mos) Observational data: n=32 5.3%-8.9% improvement in GMFM (2 fair pre-post studies)	Mixed (1 showed no benefit, 2 showed benefit)	Low due to inconsistency
F/u: Immediately posttx to 6 mos; Dose: 1.75 ATA, 60 mins; control grp received 1.2 ATA; # HBOT sessions: 20-40			
Caregiver/ PEDI 2 poor (n=137)	1 study found improved PEDI (social functioning and mobility); 1 found no difference (results NR for either study) (2 RCTs)	Mixed	Very low due to high risk of bias and inconsistency
Poor reporting			
Other outcomes 2 poor (n=280)	Observational data: 13% had improved motor function, 6% had improved cognitive abilities, and 7% had improved speech abilities 2 days posttx; 76% had reduced spasticity at 6 mos	Benefit	Very low due to high risk of bias
F/u: 2-days to 6-mos posttx; Dose: 1.5-1.7 ATA, 40-120 mins; # HBOT sessions: 20			

Hayes

55

KQ1. Cluster Headache

Outcome	Summary of Findings	Direction	QOE
Relief from cluster headaches 1 poor (n=13)	RR=11.38 (CI, 0.77-167.85) (NS) Absolute values: 6/7 pts obtained relief vs 0/6 in favor of HBOT	No benefit	Very low due to insufficient evidence
F/u: 20 mins posttx and at 8 wks; Dose: 2.5 ATA, 30 mins; # HBOT sessions:1			
Headache index (success defined as 50% reduction in index) 1 fair (n=16)	RR=0.98 (CI, 0.40-2.41) (NS)	No benefit	Very low due to insufficient evidence
F/u: 1 wk; Dose: 2.5 ATA, 70 mins; # HBOT sessions: 2			

Hayes

56

KQ1. Late Radiation Tissue Injury (cont.)

Outcome	Summary of Findings	Direction	QOE
QOL 2 good, 3 fair (n=287)	**1. Radiation proctitis** Bowel bother subscale pre-post mean improvement 14.1% HBOT grp (*P*<0.001) vs 5.8% control grp (*P*=0.15) **2. Radiation injury from head and neck cancer** Improved QOL functional outcomes at 12 mos; sticky saliva score (*P*=0.01); dry mouth (*P*=0.009); and VAS for pain in the mouth (*P*<0.0001) **3. Dental implants in irradiated field** Global QOL score MD 17.6 points (CI, 2.8-32.2) **4. Axillary radiation injury** General health MD –2.3 (CI, –19 to 14.4); 12-mo SF-36 scores 58.8 vs 61.1 (NS)	1. Benefit 2. Benefit 3. Benefit 4. No benefit	Moderate
F/u: 12 mos where reported; Dose: 2-2.5 ATA, 80-90 mins where reported; # HBOT sessions: 30-40; Time frame from radiation tx to HBOT: 2 days in 1 study; 3-mo to 3-yr hx of radiation damage elsewhere; Radiation dose: 47-70 Gy in 1 study; NR elsewhere			
LENT-SOMA scores 1 good (n=150)	LENT-SOMA mean score 5.0/14 in HBOT grp vs 2.6/14 in control grp (*P*=0.002) MD 2.4 points	Benefit	Low due to insufficient evidence
F/u: Immediately posttx; Dose: 2 ATA, 90 mins; # HBOT sessions: 30-40; Time frame from radiation tx to HBOT: NR; 3-mo hx of radiation proctitis; Radiation dose: NR			

KQ1. Late Radiation Tissue Injury (cont.)

Outcome	Summary of Findings	Direction	QOE
Loss of dental implants 1 fair (n=26)	RR=2.5 (CI, 0.59-10.64) (NS) Absolute values, 8 lost implants among HBOT grp 3 among controls	Benefit	Very low due to insufficient evidence
F/u: 1 yr; Dose: 2.5 ATA, 80 mins; # HBOT sessions: 30; Time frame from radiation tx to HBOT: NR; Radiation dose: NR			
Wound dehiscence in head and neck tissues 2 unclear (n=368)	Pooled data from 2 trials (n=368) RR=4.2 (CI, 1.1-16.8) Absolute values 6% vs 28% in favor of HBOT (I^2=70%)	Benefit	Low due to unknown risk of bias
F/u: immediately posttx; Dose: 2.4 ATA, 90 mins; # HBOT sessions: 30; Time frame from radiation tx to HBOT: NR; Radiation dose: >64 Gy			

1a. Optimal Treatment Frequency for HBOT

Indications / Outcome	Summary of Findings	QOE
Diabetic foot ulcers Rate of major amputation	Pooled data from 5 RCTS (1 good, 1 fair, 3 poor) No difference in outcome based on length of tx course <30 txs: RR=0.29; *P*=0.08 >30 txs: RR=0.40; *P*=0.29	Low due to high risk of bias and lack of direct measurement
Sensorineural hearing loss Hearing improvement	Poor-quality case series No difference based on number of tx sessions (> 30 vs <30 sessions)	Very low due to insufficient evidence
MS Mean change in EDSS	Mixed results from 2 good-quality RCTs 20 txs (RR= –0.84; 95% CI, –1.43 to –0.25) vs 20 txs plus 5 booster top-ups (RR= –0.29; 95% CI, –0.91 to 0.33) (NS) 20 txs (OR=0.34; 95% CI, 0.01-8.64; NS) vs >20 txs (OR=0.19; 95% CI, 0.05-0.73)	Very low due to inconsistency

Hayes

59

1a. Optimal Treatment Dose for HBOT

Indications / Outcome	Summary of Findings	QOE
TBI Unfavorable functional outcome	4 RCTS (3 fair, 1 poor) High tx pressure (2.5 ATA): RR=0.48; 95% CI, 0.27-0.87; *P*=0.01 Low tx pressure (1.5 ATA): RR=0.47; 95% CI, 0.08-2.85; (NS)	Low due to lack of direct measurement (subgrp analysis)
Migraine Pain relief	Fair-quality RCT HBOT was no more effective than air in relieving acute migraines (RR=6.23; 95% CI, 0.47-82.92 (NS) but better than normobaric oxygen (RR=9.0; 95% CI, 1.39-58.44; *P*=0.02)	Very low due to insufficient evidence

Hayes

60

KQ4. Cost-Effectiveness of HBOT by Indication

Indication	Cost-Effectiveness
Diabetic wounds	5 studies suggested HBOT is cost effective under the assumptions of the various models but only 1 model was robust during sensitivity analysis 2007 Canadian-based decision tree analysis: Adjunctive HBOT was dominant over standard care alone • 3.64 QALYs gained among HBOT grp vs 3.01 among controls • 12-yr pt cost CAD 40,695 (USD 40,438) for HBOT grp and CAD 49,786 (USD 49,472) for controls (2004 dollar values)
Nondiabetic nonhealing wounds	2003 MSAC of Australia: 1/3 reduction in wound size w/ HBOT: Tx costs AUD 6941 (USD 6302) per pt per 30 HBOT sessions. Cost-effectiveness (we assume a payer perspective) to cure 1 person of a chronic leg ulcer was AUD 27,764 (USD 25,210). However, the model was sensitive to the assumptions and therefore we have low confidence in the estimates provided (2013 adjusted calues).

Hayes

61

KQ4. Cost-Effectiveness of HBOT by Indication

Indication	Cost-Effectiveness
ORN	3 studies suggested HBOT is cost effective under the assumptions of the various models but all were sensitive to model assumptions. 1997 study of HBOT for ORN of the mandible: HBOT dominant over control, cost savings of CAD 53,147 (USD 60,699) (2013 adjusted)). 2001 Australian study to avoid 1 case of ORN: ICER AUD 28,480 (USD 27,366) (2013 adjusted). 2000 UK study, HBOT to treat ORN following tooth extraction in an irradiated field: Cost per pt per yr, GBP 20,000 (USD 40,271) vs GBP 5000 (USD 10,068) among non-HBOT controls. Sensitivity analysis suggested that the break-even costs of GBP 17,500 to 127,500 (USD 35,237-256,729) (2013 adjusted).
Burns	Poor-quality 1990 U.S. study found that the HBOT grp had average savings per case of $31,600 ($42,479 adjusted 2013). This result conflicts with efficacy data reported earlier, suggesting that there is insufficient evidence to support the use of HBOT for tx of burns.

Hayes

62

Undersea and Hyperbaric Medical Society (UHMS)

Indications (relevant to this report) approved by UHMC
Enhancement of Healing in Selected Problem Wounds
Delayed Radiation Injury (Soft Tissue and Bony Necrosis)
Crush Injury
Compromised Grafts and Flaps
Osteomyelitis (Refractory)
Acute Thermal Burn Injury
Idiopathic Sudden Sensorineural Hearing Loss

Hayes

63

CMS Coverage Policy

- Acute traumatic peripheral ischemia.
- Crush injuries and suturing of severed limbs.
- Acute peripheral arterial insufficiency.
- Preparation and preservation of compromised skin grafts (not for primary management of wounds).
- Chronic refractory osteomyelitis.
- Osteoradionecrosis (ORN).
- Soft tissue radionecrosis
- Diabetic wounds of the lower extremities in patients who meet the following three criteria:
  - Patient has type 1 or type 2 diabetes and has a lower extremity wound that is due to diabetes.
  - Patient has a wound classified as Wagner grade III or higher.
  - Patient has failed an adequate course of standard wound therapy.

Hayes

64

HTCC Coverage and Reimbursement Determination Analytic Tool

HTA's goal is to achieve *better health care outcomes* for enrollees and beneficiaries of state programs by paying for proven health *technologies that work*.

To find best outcomes and value for the state and the patient, the HTA program focuses on these questions:

1. Is it safe?
2. Is it effective?
3. Does it provide value (improve health outcome)?

The principles HTCC uses to review evidence and make determinations are:

Principle One: Determinations are Evidence-Based

HTCC requires scientific evidence that a health technology is safe, effective and cost-effective[1] as expressed by the following standards[2]:

- Persons will experience better health outcomes than if the health technology was not covered and that the benefits outweigh the harms.
- The HTCC emphasizes evidence that directly links the technology with health outcomes. Indirect evidence may be sufficient if it supports the principal links in the analytic framework.
- Although the HTCC acknowledges that subjective judgments do enter into the evaluation of evidence and the weighing of benefits and harms, its recommendations are not based largely on opinion.
- The HTCC is explicit about the scientific evidence relied upon for its determinations.

Principle Two: Determinations Result in Health Benefits

The outcomes critical to HTCC in making coverage and reimbursement determinations are health benefits and harms[3]:

- In considering potential benefits, the HTCC focuses on absolute reductions in the risk of outcomes that people can feel or care about.
- In considering potential harms, the HTCC examines harms of all types, including physical, psychological, and non-medical harms that may occur sooner or later as a result of the use of the technology.
- Where possible, the HTCC considers the feasibility of future widespread implementation of the technology in making recommendations.
- The HTCC generally takes a population perspective in weighing the magnitude of benefits against the magnitude of harms. In some situations, it may make a determination for a technology with a large potential benefit for a small proportion of the population.
- In assessing net benefits, the HTCC subjectively estimates the indicated population's value for each benefit and harm. When the HTCC judges that the balance of benefits and harms is likely to vary substantially within the population, coverage or reimbursement determinations may be more selective based on the variation.
- The HTCC considers the economic costs of the health technology in making determinations, but costs are the lowest priority.

[1] Based on legislative mandate: See RCW 70.14.100(2).

[2] The principles and standards are based on USPSTF Principles at: http://www.ahrq.gov/clinic/ajpmsuppl/harris3.htm

[3] The principles and standards are based on USPSTF Principles at: http://www.ahrq.gov/clinic/ajpmsuppl/harris3.htm

Using Evidence as the Basis for a Coverage Decision

Arrive at the coverage decision by identifying for Safety, Effectiveness, and Cost whether (1) evidence is available, (2) the confidence in the evidence, and (3) applicability to decision.

1. *Availability of Evidence:*

Committee members identify the factors, often referred to as outcomes of interest, that are at issue around safety, effectiveness, and cost. Those deemed key factors are ones that impact the question of whether the particular technology improves health outcomes. Committee members then identify whether and what evidence is available related to each of the key factors.

2. *Sufficiency of the Evidence:*

Committee members discuss and assess the evidence available and its relevance to the key factors by discussion of the type, quality, and relevance of the evidence[4] using characteristics such as:

- Type of evidence as reported in the technology assessment or other evidence presented to committee (randomized trials, observational studies, case series, expert opinion);
- The amount of evidence (sparse to many number of evidence or events or individuals studied);
- Consistency of evidence (results vary or largely similar);
- Recency (timeliness of information);
- Directness of evidence (link between technology and outcome);
- Relevance of evidence (applicability to agency program and clients);
- Bias (likelihood of conflict of interest or lack of safeguards).

Sufficiency or insufficiency of the evidence is a judgment of each clinical committee member and correlates closely to the GRADE confidence decision.

Not Confident	Confident
Appreciable uncertainty exists. Further information is needed or further information is likely to change confidence.	Very certain of evidentiary support. Further information is unlikely to change confidence.

3. *Factors for Consideration - Importance*

At the end of discussion a vote is taken on whether sufficient evidence exists regarding the technology's safety, effectiveness, and cost. The committee must weigh the degree of importance that each particular key factor and the evidence that supports it has to the policy and coverage decision. Valuing the level of importance is factor or outcome specific but most often include, for areas of safety, effectiveness, and cost:

- Risk of event occurring;
- The degree of harm associated with risk;
- The number of risks; the burden of the condition;
- Burden untreated or treated with alternatives;
- The importance of the outcome (e.g. treatment prevents death vs. relief of symptom);
- The degree of effect (e.g. relief of all, none, or some symptom, duration, etc.);
- Value variation based on patient preference.

[4] Based on GRADE recommendation: http://www.gradeworkinggroup.org/FAQ/index.htm

Medicare Coverage and Guidelines (Pages 92 - 101 of Final Report)

Medicare (pages 99-101)
Centers for Medicare & Medicaid Services (CMS)

Centers for Medicare & Medicaid Services (CMS). Medicare Coverage Database. NCD for Hyperbaric Oxygen Therapy (20.29). Revised June 19, 2006. Available at: http://www.cms.gov/medicare-coverage-database/details/ncd-details.aspx?NCDId=12&ncdver=3.

CMS covers HBOT administered in either a monoplace or multi-chamber for a number of indications. Covered conditions include the following (for a complete picture, we included all conditions covered by CMS in relation to HBOT irrespective of whether they were the focus of this report):

- Acute carbon monoxide intoxication.
- Decompression illness.
- Gas embolism.
- Gas gangrene.
- Acute traumatic peripheral ischemia. HBOT is a valuable adjunctive treatment to be used in combination with accepted standard therapeutic measures when loss of function, limb, or life is threatened.
- Crush injuries and suturing of severed limbs. As in the previous conditions, HBOT would be an adjunctive treatment when loss of function, limb, or life is threatened.
- Progressive necrotizing infections (necrotizing fasciitis).
- Acute peripheral arterial insufficiency.
- Preparation and preservation of compromised skin grafts (not for primary management of wounds).
- Chronic refractory osteomyelitis, unresponsive to conventional medical and surgical management.
- ORN as an adjunct to conventional treatment.
- Soft tissue radionecrosis as an adjunct to conventional treatment.
- Cyanide poisoning.
- Actinomycosis, only as an adjunct to conventional therapy when the disease process is refractory to antibiotics and surgical treatment.
- Diabetic wounds of the lower extremities in patients who meet the following three criteria:
  - Patient has type 1 or type 2 diabetes and has a lower extremity wound that is due to diabetes.
  - Patient has a wound classified as Wagner grade III or higher.
  - Patient has failed an adequate course of standard wound therapy.

The use of HBOT is covered as adjunctive therapy only after there are no measurable signs of healing for at least 30 days of treatment with standard wound therapy and must be used in addition to standard wound care. Standard wound care in patients with diabetic wounds includes: assessment of a patient's vascular status and correction of any vascular problems in the affected limb if possible; optimization of nutritional status; optimization of glucose control; debridement by any means to remove devitalized tissue; maintenance of a clean, moist bed of granulation tissue with appropriate moist dressings, appropriate off-loading, and necessary treatment to resolve any infection that might be present. Failure to respond to standard wound care occurs when there are no measurable signs of healing for at least 30 consecutive days. Wounds must be evaluated at least every 30 days during administration of HBOT. Continued treatment with HBOT is not covered if measurable signs of healing have not been demonstrated within any 30-day period of treatment. All other indications not specified above are not covered under the Medicare program. No program payment may be made for any conditions other than those listed above. No program payment may be made for HBOT in the treatment of the following conditions:

- Cutaneous, decubitus, and stasis ulcers.
- Chronic peripheral vascular insufficiency.
- Anaerobic septicemia and infection other than clostridial.

- Skin burns (thermal).
- Senility.
- Myocardial infarction.
- Cardiogenic shock.
- Sickle cell anemia.
- Acute thermal and chemical pulmonary damage, i.e., smoke inhalation with pulmonary insufficiency.
- Acute or chronic cerebral vascular insufficiency.
- Hepatic necrosis.
- Aerobic septicemia.
- Nonvascular causes of chronic brain syndrome (Pick's disease, Alzheimer's disease, Korsakoff's disease).
- Tetanus.
- Systemic aerobic infection.
- Organ transplantation.
- Organ storage.
- Pulmonary emphysema.
- Exceptional blood loss anemia.
- Multiple sclerosis.
- Arthritic diseases.
- Acute cerebral edema.

Since HBOT for the treatment of sensorineural hearing loss, TBI, other brain injuries, and cerebral palsy do not appear on the list of covered conditions, we can assume that there is no reimbursement coverage for these conditions (CMS, 2012).

Table 5. Evidence Source and Quality Assessment for Included Guidelines

Author and Date Organization	Indication/ Subgroup	Evidence Source Employed by the Guideline	AGREE Quality Assessment (Scale 0-7)
European Committee for Hyperbaric Medicine (ECHM) and European Tissue Repair Society (ETRS) (Niinikoski et al., 2007)	Cross-cutting	Not reported	6
Wound Healing Society (Hopf et al., 2006)	Cross-cutting	Previous guidelines; MEDLINE; Embase; Cochrane Library; reviews of arterial ulcer treatment; Medicare/Centers for Medicare & Medicaid Services (CMS)	5
NICE (2011)	Diabetic foot	Allied and Complementary Medicine Database; British Nursing Index; Health Business Elite; Cochrane Database of Systematic Reviews (CDSR); Cochrane Central Register of Controlled Trials (CENTRAL); Database of Abstracts of Reviews of Effects (DARE); health technology assessments (HTAs); CINAHL; Embase (Ovid); Health Management Information Consortium (HMIC); MEDLINE; PsycINFO	6
Wound Healing Society (2006)	Diabetic foot ulcers	Previous guidelines; MEDLINE; Embase; Cochrane Library; recent reviews of diabetic foot ulcers; Medicare/CMS consensus of usual treatment of chronic wounds	5
Institute for Clinical Systems Improvement (ICSI) (2012)	Pressure ulcers	Electronic databases (specifics NR)	5
European Pressure Ulcer Advisory Panel and National Pressure Ulcer Advisory Panel (2009)	Pressure ulcers	PubMed; CINAHL; Embase; CDSR; Cochrane Central; Register of Controlled Trials; HTAs; Allied and Alternative Medicine Database (AMED) (inclusive dates January 1998 – January 2008); 13 sets of pressure ulcer guidelines (approximately 3000 published manuscripts reviewed)	7

Author and Date Organization	Indication/ Subgroup	Evidence Source Employed by the Guideline	AGREE Quality Assessment (Scale 0-7)
Registered Nurses' Association of Ontario (2007)	Pressure ulcers	MEDLINE; Embase; CINAHL	6
Association for the Advancement of Wound Care (2010)	Pressure ulcers	Manual searches of published literature (primary sources); manual searches of published Literature (secondary sources); searches of electronic databases; searches of unpublished data	6
Department of Veterans Affairs (VA)/Department of Defense (DOD) (2007)	Management of lower extremity amputations	MEDLINE/PubMed; DARE; CENTRAL	5
Wound, Ostomy and Continence Nurses Society (Bonham et al., 2008)	Nonhealing ischemic wounds	MEDLINE; CINAHL; Cochrane Library	5
American Academy of Otolaryngology – Head and neck Surgery (Stachler et al., 2012)	Sudden sensorineural hearing loss	National Guideline Clearinghouse; Cochrane Library; CINAHL; Embase; PubMed; Web of Science; BIOSIS; CENTRAL; CAB Abstracts; CMA Infobase; NHS Evidence; ENT and Audiology; National Library of Guidelines; NICE; Scottish Intercollegiate Guidelines Network (SIGN), New Zealand Guidelines Group (NZGG); Australian National Health and Medical Research Council; Tripdatabase; DARE HTA Database; Health Services Technology Assessment Texts (HSTAT)	7
Agence d'Evaluation des Technologies et des Modes d'Intervention en Sante (AETMIS) (2007)	Cerebral palsy	CINAHL; dissertation abstracts; Cochrane Library; psychological abstracts; PubMed; Embase; World of Science; textbooks; websites of the Undersea and Hyperbaric Medical Society (UHMS), National Institute of Neurological Disorders and Stroke (NINDS), United Cerebral Palsy Association	5
Dutch Head and Neck Oncology Cooperative Group (2007)	Osteoradionecrosis (ORN)	Cochrane Library; MEDLINE; Embase; CINAHL; PsycINFO	5
Weaver (2011)	Critically ill intubated, mechanically ventilated patients	MEDLINE; research repository of the Rubicon Foundation to find publications not indexed in PubMed; abstracts and reports presented at scientific meetings; clinical trial registries	2

HEALTH TECHNOLOGY EVIDENCE IDENTIFICATION

Discussion Document: What are the key factors and health outcomes and what evidence is there?

Safety Outcomes	Safety Evidence
Death	
Persistent ocular changes	
Ear Barotrauma	
Sinus barotrauma	
Pulmonary barotrauma	
Claustrophobia	
Central nervous system seizures	
Pulmonary oxygen toxicity	
Pulmonary edema	
Ear pain	
Sinus pain	
Abdominal pain	
Hypoxia	
Joint pain	
Toothache	
General pain or discomfort during compression	
Tympanostomy tube placement	
Efficacy – Effectiveness Outcomes	**Efficacy / Effectiveness Evidence**
Diabetic non-healing wounds	
Incidence of healing	
Amputation rates	
QOL	

Wound size reduction	
Nondiabetic Nonhealing Wounds	
Venous,arterial pressure ulcers	
Compromised grafts and flaps	
Surgical reconstruction (w/o grafts or flaps)	
Crush injuries	
Thermal burns	
Acute traumatic peripheral ischemia	
Refractory Osteomylitis	
Resolution/cure	
Infection relapse rate	
# days in hospital	
Late Radiation Tissue Injury	
Complete resolution or improvement of tissue damage or necrosis	
Prevention of ORN after tooth extraction	
Complete mucosal cover and establishment of bony continuity for ORN	
QOL	
Improvement in late effects of radiation (LENTSOMA scores)	
Loss of dental implants	
Wound dehiscence in head and neck tissues	
Brain Injury- TBI	

Mortality among pts w/ TBI)	
Functional outcomes among pts w/ TBI	
Brain Injury- non-TBI	
Mortality among pts w/ non-TBI brain injuries	
Functional outcomes among non-TBI brain injury pts	
Symptoms among non-TBI brain injury pts	
Cerebral Palsy	
Motor function	
Caregiver/PEDI	
Other disease-specific outcomes	
Multiple Sclerosis	
Reduction in EDSS	
Prevention of exacerbation	
FSS	
Migraine	
Migraine relief	
Reduction in nausea and vomiting	
Need for rescue medication	
Migraine pain intensity	
Cluster Headache	
Relief from cluster headaches	
Headache index (success defined as 50% reduction in index)	
Sensorineural Hearing Loss	
Hearing improvement/ recovery in acute sensorineural hearing loss	

Hearing improvement/ recovery in chronic sensorineural hearing loss	
Special Population / Considerations Outcomes	**Special Population Evidence**
Age	
Sex	
Race	
Ethnicity	
Disability	
Comorbidities	
Wound or injury duration and severity	
Treatment Setting	
Cost	**Cost Evidence**
Cost-effectiveness	

Clinical Committee Evidence Votes

First Voting Question
The HTCC has reviewed and considered the technology assessment and information provided by the administrator, reports and/or testimony from an advisory group, and submissions or comments from the public. The committee has given greatest weight to the evidence it determined, based on objective factors, to be the most valid and reliable.

Is there sufficient evidence under some or all situations that the technology is:

	Unproven (no)	**Equivalent** (yes)	**Less** (yes)	**More** (yes)
Effective				
Safe				
Cost-effective				

Discussion
Based on the evidence vote, the committee may be ready to take a vote on coverage or further discussion may be warranted to understand the differences of opinions or to discuss the implications of the vote on a final coverage decision.

- Evidence is insufficient to make a conclusion about whether the health technology is safe, efficacious, and cost-effective;
- Evidence is sufficient to conclude that the health technology is unsafe, ineffectual, or not cost-effective
- Evidence is sufficient to conclude that the health technology is safe, efficacious, and cost-effective for all indicated conditions;
- Evidence is sufficient to conclude that the health technology is safe, efficacious, and cost-effective for some conditions or in some situations

A straw vote may be taken to determine whether, and in what area, further discussion is necessary.

Second Vote
Based on the evidence about the technologies' safety, efficacy, and cost-effectiveness, it is

_____Not Covered _____ Covered Unconditionally _____ Covered Under Certain Conditions

Discussion Item

Is the determination consistent with identified Medicare decisions and expert guidelines, and if not, what evidence is relied upon.

Clinical Committee Findings and Decisions

Next Step: Cover or No Cover
If not covered, or covered unconditionally, the Chair will instruct staff to write a proposed findings and decision document for review and final adoption at the following meeting.

Next Step: Cover with Conditions
If covered with conditions, the Committee will continue discussion.

1) Does the committee have enough information to identify conditions or criteria?
   - Refer to evidence identification document and discussion.
   - Chair will facilitate discussion, and if enough members agree, conditions and/or criteria will be identified and listed.
   - Chair will instruct staff to write a proposed findings and decision document for review and final adoption at next meeting.

2) If not enough or appropriate information, then Chair will facilitate a discussion on the following:
   - What are the known conditions/criteria and evidence state
   - What issues need to be addressed and evidence state

The chair will delegate investigation and return to group based on information and issues identified. Information known but not available or assembled can be gathered by staff ; additional clinical questions may need further research by evidence center or may need ad hoc advisory group; information on agency utilization, similar coverage decisions may need agency or other health plan input; information on current practice in community or beneficiary preference may need further public input. Delegation should include specific instructions on the task, assignment or issue; include a time frame; provide direction on membership or input if a group is to be convened.

Efficacy Considerations:

- What is the evidence that use of the technology results in more beneficial, important health outcomes? Consider:
  - Direct outcome or surrogate measure
  - Short term or long term effect
  - Magnitude of effect
  - Impact on pain, functional restoration, quality of life
  - Disease management
- What is the evidence confirming that use of the technology results in a more beneficial outcome, compared to no treatment or placebo treatment?
- What is the evidence confirming that use of the technology results in a more beneficial outcome, compared to alternative treatment?
- What is the evidence of the magnitude of the benefit or the incremental value
- Does the scientific evidence confirm that use of the technology can effectively replace other technologies or is this additive?
- For diagnostic tests, what is the evidence of a diagnostic tests' accuracy
  - Does the use of the technology more accurately identify both those with the condition being evaluated and those without the condition being evaluated?
- Does the use of the technology result in better sensitivity and better specificity?
- Is there a tradeoff in sensitivity and specificity that on balance the diagnostic technology is thought to be more accurate than current diagnostic testing?
- Does use of the test change treatment choices?

Safety

- What is the evidence of the effect of using the technology on significant morbidity?
    - Frequent adverse effect on health, but unlikely to result in lasting harm or be life-threatening, or;
    - Adverse effect on health that can result in lasting harm or can be life-threatening.
- Other morbidity concerns
- Short term or direct complication versus long term complications
- What is the evidence of using the technology on mortality – does it result in fewer adverse non-fatal outcomes?

Cost Impact

- Do the cost analyses show that use of the new technology will result in costs that are greater, equivalent or lower than management without use of the technology?

Overall

- What is the evidence about alternatives and comparisons to the alternatives
- Does scientific evidence confirm that use of the technology results in better health outcomes than management without use of the technology?