First Aid Data Tables: Characteristics of Included Articles in ScopRev of Use of Supplementary Oxygen in First Aid

Table 1: Carbon Monoxide Poisoning

Author; Year Published	Study Type	Setting	Population	Intervention	Comparison	Outcomes	Results/Key findings
Smith 1970[1]	Retrospective case series	Prehospital and hospital emergency departments	Accidental and deliberate carbon monoxide (CO) poisoning (N=206)	Oxygen, oxygen carbon dioxide mixture, hyperbaric oxygen	No supplementary oxygen	Delirium, persistent psychiatric symptoms	Mostly epidemiological study. Found fewer persistent symptoms if oxygen administered, advised oxygen carbon dioxide mixture if hyperbaric oxygen not available.
Winter 1976[2]	Literature review	Pre- and in-hospital	Persons with carbon monoxide poisoning	100% oxygen as first aid, hyperbaric oxygen in hospital	Not specified	Reversal of hypoxemia and accelerated elimination of CO	Authors recommended 100% oxygen at atmospheric or hyperbaric pressures to reverse hypoxemia and accelerate CO elimination.
Olson 1984[3]	Literature review	Pre- and in hospital	Persons with carbon monoxide poisoning	100% oxygen as soon as possible, multiple non-first aid	Not specified	Time to resolution of neurological and neuro-psychiatric symptoms	Recommends 100% oxygen as soon as carbon monoxide poisoning suspected, using a tight-fitting mask to deliver the highest percent oxygen.
Koster 2003[4]	Literature review	Pre- and in hospital	Persons with carbon monoxide poisoning	100% oxygen, recompression chamber if available	None	Not specified	The authors recommend administration of 100% oxygen.

Kao 2006[1]	Literature review	Pre- and in hospital	Persons with carbon monoxide poisoning	Supplementary oxygen and hyperbaric oxygen	None	Not specified	Authors recommend supplemental oxygen and other supportive care.
Jüttner 2021[5]	Evidence based guideline	Pre- and in hospital	Persons with carbon monoxide poisoning	100% oxygen	None	Not specified	Authors recommend immediate administration of oxygen at the highest available concentration.

Table 2: Diving Emergencies

Author; Year Published	Study Type	Setting	Population	Intervention	Comparison	Outcomes	Results/Key findings
Dick 1985[6]	Retrospective case series	Pre- and in hospital	Scuba divers with DCI (N= 70) and air embolism (N=39)	100% oxygen	No oxygen treatment	Neurological decompression illness and cerebral air aneurysm	Authors describe improvement in cases where oxygen was administered immediately for decompression sickness or air embolism.
Shinnick 1994[7]	Literature review	Pre- and in hospital	Divers with compressed gas (probably recreational)	100% oxygen as first aid, hyperbaric oxygen in hospital	No oxygen treatment	Prevention of "permanent disability or even death"	Review focuses on delay in the initiation of treatment for diving emergencies and calls for emergency physicians to contact Divers Alert Network (DAN). Authors also emphasize the importance of the administration of 100% oxygen.
Spira 1999[8]	Literature Review	EMS and in	Divers with barotra	100% oxygen during	Not specified	Prevention of sequelae	Advises 100% oxygen during transport to a facility where hyperbaric

		hospital	uma include air embolism and DCI	transfer to unit with hyperbaric oxygen		of diving injuries	oxygen can be administered.
Lippmann 2003[9]	Proceedings of conference	Prehospital	Divers with DCI	100% oxygen	Not specified	Relief of symptoms, post treatment residua	Authors emphasize the importance of having oxygen equipment that can provide high oxygen concentrations to responsive or unresponsive victims of diving emergencies.
Longphre 2007[10]	Retrospective cohort, 2,231 individuals	Prehospital	Divers using compressed gas (N = 2231)	"First aid oxygen" prehospital	No first aid supplementary oxygen	Resolution of symptoms and number of retreatment recompression	Authors noted that oxygen decreased the number of recompression treatments needed if administered within 4 hours of surfacing.
Liow 2009[11]	Retrospective case series	Hospital and prehospital	Divers with DCI (N = 3)	Hyperbaric oxygen (HBO) and normobaric 100% oxygen	None	Neurological recovery	Recommends 100% normobaric oxygen until recompression therapy.
Moon 2009 81[12]	Literature review	Pre and in hospital	Recreational divers with DCI	First aid oxygen prehospital, multiple other in-hospital interventions	Not specified	Resolution of symptoms and need for more than one recompression treatment	Recommends oxygen administration within 4 hours of injury based on Longphre study[10] findings.
Vann 2011[13]	Literature review published in seminar	Pre- and in hospital	Divers using compressed gas	100% oxygen in prehospital setting	Not specified	Recovery from diving injury, symptom resolution	Recommends the administration of 100% oxygen(O2) for several hours, even after symptom resolution.

	proceedings						
Blake 2020[14]	Laboratory	Laboratory	Healthy volunteer divers (N = 12)	Oxygen breathed from 1) demand valve with intraoral mask and nose clip or 2) medical oxygen rebreathing system with oronasal mask and with intraoral mask	NRB with oxygen at 15 or 10 L/min	Transcutaneous measurement of tissue oxygen partial pressure in limbs	Tissue oxygen partial pressure and nasopharyngeal inspired oxygen concentrations similar with demand valve with intraoral mask, medical O2 rebreathing system with oronasal or intraoral mask, and NRB with flow rate 15 L/min. Values lower for NRB at flow rate 10 L/min.
Pollock. 2017[15]	Literature Review	Pre- and in hospital	Recreational divers (compressed gases including air, nitrogen and helium mixtures	High partial pressure oxygen	Not specified	Not specified	Concludes that high partial pressure oxygen is the primary first aid measure for DCI, can use continuous flow with NRB or pocket mask in diving environment, but higher oxygen fraction can be achieved in spontaneously breathing patients with mask and demand valve and rebreather systems.
Whayne 2018[16]	Literature Review	Pre- and in hospital	Commercial and recreational divers using compressed gases	100% oxygen in prehospital setting	Not specified	"Decrease complications and save lives"	Authors recommends immediate administration of 100% oxygen and rehydration with intravenous isotonic fluids until hyperbaric oxygen therapy is available.

Abbreviations:

EMS Emergency Medical Service
NRB Non-rebreather mask
DCI Decompression Illness

Table 3. Chronic Obstructive Pulmonary Disease

Author; Year Published	Study Type	Setting	Population	Intervention	Comparison	Outcomes	Results/Key findings
Austin 2006[17]	Systematic review of randomized controlled trials (RCTs)	Pre hospital	Acute exacerbation of Chronic obstructive pulmonary disease (AECOPD)	High flow oxygen. Not defined except subgroup of flow for nebulized bronchodilators – "typically 6-8L/min"	"Controlled" oxygen	Mortality from respiratory causes *Secondary outcomes* 1. All cause mortality 2. Dyspnea score 3. Arterial blood gas (ABG) 4. Length of stay (LOS) 5. ICU admission 6. Mental status score 7. Consciousness score (i.e., GCS) 8. Invasive ventilation 9. Noninvasive ventilation 10.Lung function 11.Illness score	Only 2 RCTs were identified and were ongoing with no results published at the time of the review.
Austin 2010[18]	Cluster randomized trial	Prehospital	COPD, including AECOPD	Oxygen titrated to saturations of 88-	High concentration oxygen: High	Mortality, respiratory acidosis, hypercapnia,	Titrated oxygen treatment significantly reduced mortality, hypercapnia, and respiratory acidosis

			(N = 405)	92%; nebulized bronchodilators delivered with compressed air. (N=179)	flow oxygen treatment (8–10 L/min) administered via a non-rebreather face mask and bronchodilators delivered by nebulization with oxygen flows of 6–8 l/min. (N= 226)		compared with high flow oxygen in acute exacerbations of chronic obstructive pulmonary disease.
Ntoumenopoulos 2011 70008[19]	Review with Commentary	Prehospital	AECOPD	Titrated oxygen by NC to sat 88%-92%	High flow oxygen (8-10 L/min) via NRM	Pre- and in-hospital mortality; length of stay, ABGs.	Synopsis of Austin 2010[18] study with commentary and review of risk of hypercarbia with high concentration oxygen therapy, current guidelines for oxygen delivery with AECOPD.
Wijesinghe 2011[20]	Retrospective observational	Prehospital	AECOPD patients transported by ambulance (N = 250)	Oxygen administration at >/= 3 L/min (N=168/92%), >/=8 L/min, defined as high flow, via	Oxygen administration at <3 L/min (defined as low flow)	Death, required assisted ventilation, respiratory failure	When oxygen delivery was analyzed as a continuous variable according to documented flow rate, Increased oxygen flow was associated with increased risk of death, assisted ventilation or respiratory failure with an odds ratio (OR) of 1.2 (95% CI 1.0–1.4)

				NC, mask or NRM (N=90; 49%)			per 1 L/min oxygen flow. Increasing PaO2 was associated with a greater risk of a poor outcome with an OR of 1.1 (95% CI 1.0–1.3) per 10 mmHg higher PaO2. A nonsignificant association was reported for the dichotomous “high flow” vs. “low flow” oxygen for the main outcome composite of death, positive pressure ventilation or respiratory failure.
Cameron 2012[21]	Retrospective observational	Prehospital	AECOPD patients transported by ambulance who had ABG within 4 hours of triage (N=254)	Oxygen saturation on ABG within 4 hours of arrival in ED <88% or >96%	Oxygen saturation on ABG within 4 hours of arrival in ED 88-92%	Composite measure of hypercapnic respiratory failure, assisted ventilation or inpatient death	Adverse clinical outcomes were associated with both hypoxemia (OR 2.16, 95% CI 1.11 to 4.20) and hyperoxemia (OR 9.17, 95% CI, 4.08-20.6) compared with normoxemia (OR 2.16, 95% CI, 1.11 - 4.20). Results support titrating oxygen to target oxygen saturation.
Pilcher 2015[22]	Literature Review	Pre- and in hospital	AECOPD	Titrated oxygen and air-driven nebulization of bronchodilators	High concentration or high dose oxygen	Mortality	Authors describe evidence from Austin[18] of mortality risk if patients with AECOPD received high concentration oxygen, guidelines for use of oxygen only if SpO2 <88%, titration-to 88-92%, use of air-driven delivery of nebulized bronchodilators.
Ringbaek 2015[23]	Observational study	Pre- and in-hospital	AECOPD patients transported by	Oxygen, varying flow rates	Oxygen, varying flow rates	Respiratory acidosis at hospital admission, length of	Review aimed to assess the frequency of “inappropriate oxygen therapy” (determined by an oxygen saturation of

			ambulance who received any oxygen (N=405)			stay, ventilatory support, in-hospital mortality	92% or greater) given in ambulance for AECOPD patients. A total of 352 (88.7%) of 397 patients were deemed to have received inappropriate oxygen therapy based on an O2 saturation of 92% or greater. Of this group of patients, 33.5% had respiratory acidosis at hospital admission.
Lumholdt 2017[24]	Retrospective observational; Abstract	Prehospital	Patients brought to Emergency Department (ED) with "respiratory conditions" EMS care only provided with 100% oxygen. (N=125)	CO_2 retention	No CO_2 retention	Hypercapanic acidosis due to excessive prehospital oxygen	11 patients with respiratory conditions brought to ED by EMS and found to have CO2 retention and acidosis. The mean oxygen saturation of the 11 patients with CO_2 retention was 84% on presentation to EMS and 95% on arrival in ED. They inferred this was due to excessive oxygen administration before arrival in hospital.
Bentsen 2020[25]	Retrospective observational	Pre-hospital	COPD transported to hospital by Emergency Medical Services (EMS) before and after implementing a	High flow Oxygen	Titrated oxygen	30-day mortality	30-day mortality of 56 patients with AECOPD treated with high-flow oxygen was 11.5% vs 9.4% in the titrated oxygen group (P=0.41). A change of treatment protocols to titrated oxygen was associated with a lower 30-day mortality for patients with an acute exacerbation of COPD, but not for all COPD patients.

			change in prehospital oxygen protocoled from high flow to titrated oxygen. N=707				
Kopsaftis 2020[26]	Cochrane review	Pre-hospital EMS	Adults with acute exacerbation of COPD	"Controlled oxygen"	"Standard oxygen" cited in the single paper as: High concentration oxygen: High flow oxygen treatment (8–10 L/min) administered via a non-rebreather face mask and bronchodilators delivered by nebulization with oxygen flows of	"Mortality"	The one included study (Austin)[18] found a reduction in pre/in-hospital mortality for the titrated oxygen arm compared to the high-flow control arm. However, the paucity of evidence limits the reliability of these findings and generalizability to other settings.

					6–8 l/min.		
Hodroge 2020[27]	Evidence Based Guideline	Prehospital	Adult patients with respiratory distress	Titrated Oxygen	High Flow oxygen (not defined)	Mortality	Concluded that titration of oxygen to 94-96% for most patients and 88-92% for those with AECOPD was associated with lower mortality.
Barnett 2022[28]	Evidence based guideline	Pre- and in hospital	COPD	N/A	N/A	N/A	Key recommendations: assess oxygenation, oxygen requires prescription and to set oxygen saturation targets of 88-92% for individuals with potential hypercapnia and 92-96% for others.
Gottlieb 2022[29]	Evidence based guideline.	Prehospital	All patients considered for supplementary oxygen	titrated oxygen	High flow oxygen	Mortality and “functional outcome"	Recommends the use of pulse oximetry to assess the need for oxygen before administering it, except for in critical situations (e.g. during CPR).
Jensen 2023[30]	Randomized control trial study protocol	Prehospital, gas used to drive inhaled bronchodilators (Planned N=1,888)	AECOPD	Titrated oxygen and compressed air driven inhaled bronchodilators to target SpO2 (oxygen saturation) 88-92%	Standard high flow oxygen	30-day mortality	Protocol for RCT comparing targeted prehospital oxygen therapy with standard high concentration/flow oxygen.
Gude NCT05703919[31]	Randomized control trial registered in USA. (Same	Prehospital, gas used to drive inhale	AECOPD	Titrated oxygen and compressed air driven inhaled	Standard high flow oxygen	30-day mortality	N/A not completed

	trial as Jensen 2023 published study protocol.)	d bronc hodila tors		broncho dilators to target SpO2 (oxygen saturatio n) 88-92%			

Abbreviations Table 1-3:
ABG, arterial blood gas; AECOPD, acute exacerbation of COPD; CI, confidance interval; CO_2, carbon dioxide; COPD, chronic obstructive pulmonary disease; CPR; cardiopulmonary resuscitation; ED, emergency department; EMS, emergency medical services; GCS, Glasgow coma scale; HR, hazard ratio; ICU, intensive care unit; L/min, liters per minute; LOS, length of stay; N/A, not applicable; NC,nasal cannula; NRM, nonrebreather face mask; OR, odds ratio; RCT, randomized controlled trial; RR, relative risk

REFERENCES

1. Kao LW, Nanagas KA. Toxicity associated with carbon monoxide. *Clin Lab Med*. 2006;26:99-125. doi: 10.1016/j.cll.2006.01.005
2. Winter PM, Miller JN. Carbon monoxide poisoning. *Jama*. 1976;236:1502.
3. Olson KR. Carbon monoxide poisoning: mechanisms, presentation, and controversies in management. *J Emerg Med*. 1984;1:233-243. doi: 10.1016/0736-4679(84)90078-7
4. Koster LA, Rupp T. The silent killer: recognizing & treating carbon monoxide poisoning. *JEMS*. 2003;28:80-87; quiz 88-89.
5. Juttner B, Busch HJ, Callies A, Dormann H, Janisch T, Kaiser G, Korner-Gobel H, Kluba K, Kluge S, Leidel BA, et al. S2k guideline diagnosis and treatment of carbon monoxide poisoning. *Ger Med Sci*. 2021;19:Doc13. doi: 10.3205/000300
6. Dick AP, Massey EW. Neurologic presentation of decompression sickness and air embolism in sport divers. *Neurology*. 1985;35:667-671. doi: 10.1212/wnl.35.5.667
7. Shinnick MA. Recognition of scuba diving accidents and the importance of oxygen first aid. *J Emerg Nurs*. 1994;20:105-110.
8. Spira A. Diving and marine medicine review part II: diving diseases. *J Travel Med*. 1999;6:180-198. doi: 10.1111/j.1708-8305.1999.tb00857.x
9. Lippmann J. First aid oxygen administration for divers. *South Pacific Underwater Medicine Society Journal*. 2003;33
10. Longphre JM, Denoble PJ, Moon RE, Vann RD, Freiberger JJ. First aid normobaric oxygen for the treatment of recreational diving injuries. *Undersea Hyperb Med*. 2007;34:43-49.
11. Liow MH, Chong SJ, Kang WL. A tale of three divers: recompression therapy for divers with severe Type II decompression sickness with neurological deficits. *Singapore Med J*. 2009;50:e173-175.
12. Moon RE. Adjunctive therapy for decompression illness: a review and update. *Diving Hyperb Med*. 2009;39:81-87.
13. Vann RD, Butler FK, Mitchell SJ, Moon RE. Decompression illness. *Lancet*. 2011;377:153-164. doi: 10.1016/s0140-6736(10)61085-9
14. Blake DF, Crowe M, Lindsay D, Brouff A, Mitchell SJ, Leggat PA, Pollock NW. Comparison of tissue oxygenation achieved breathing oxygen using different delivery

devices and flow rates. *Diving Hyperb Med*. 2020;50:34-42. doi: 10.28920/dhm50.1.34-42
15. Pollock NW, Buteau D. Updates in Decompression Illness. *Emerg Med Clin North Am*. 2017;35:301-319. doi: 10.1016/j.emc.2016.12.002
16. Whayne TF. Medical Management and Risk Reduction of the Cardiovascular Effects of Underwater Diving. *Curr Vasc Pharmacol*. 2018;16:344-354. doi: 10.2174/1570161115666170621084316
17. Austin M, Wood-Baker R. Oxygen therapy in the pre-hospital setting for acute exacerbations of chronic obstructive pulmonary disease. *Cochrane Database Syst Rev*. 2006:Cd005534. doi: 10.1002/14651858.CD005534.pub2
18. Austin MA, Wills KE, Blizzard L, Walters EH, Wood-Baker R. Effect of high flow oxygen on mortality in chronic obstructive pulmonary disease patients in prehospital setting: randomised controlled trial. *Bmj*. 2010;341:c5462. doi: 10.1136/bmj.c5462
19. Ntoumenopoulos G. Using titrated oxygen instead of high flow oxygen during an acute exacerbation of chronic obstructive pulmonary disease (COPD) saves lives. *J Physiother*. 2011;57:55. doi: 10.1016/S1836-9553(11)70008-X
20. Wijesinghe M, Perrin K, Healy B, Hart K, Clay J, Weatherall M, Beasley R. Pre-hospital oxygen therapy in acute exacerbations of chronic obstructive pulmonary disease. *Intern Med J*. 2011;41:618-622. doi: 10.1111/j.1445-5994.2010.02207.x
21. Cameron L, Pilcher J, Weatherall M, Beasley R, Perrin K. The risk of serious adverse outcomes associated with hypoxaemia and hyperoxaemia in acute exacerbations of COPD. *Postgrad Med J*. 2012;88:684-689. doi: 10.1136/postgradmedj-2012-130809
22. Pilcher J, Weatherall M, Perrin K, Beasley R. Oxygen therapy in acute exacerbations of chronic obstructive pulmonary disease. *Expert Rev Respir Med*. 2015;9:287-293. doi: 10.1586/17476348.2015.1016503
23. Ringbaek TJ, Terkelsen J, Lange P. Outcomes of acute exacerbations in COPD in relation to pre-hospital oxygen therapy. *Eur Clin Respir J*. 2015;2. doi: 10.3402/ecrj.v2.27283
24. Lumholdt M, Cresciolo E, Monti A, Sørensen LR, Damgaard KA. Abstract 19: Pre-hospital oxygen therapy and CO2 retention in patients admitted through the emergency department. *BMJ Open*. 2017;7:A1 - A18.
25. Bentsen LP, Lassen AT, Titlestad IL, Brabrand M. A change from high-flow to titrated oxygen therapy in the prehospital setting is associated with lower mortality in COPD patients with acute exacerbations: an observational cohort study. *Acute Med*. 2020;19:76-82.
26. Kopsaftis Z, Carson-Chahhoud KV, Austin MA, Wood-Baker R. Oxygen therapy in the pre-hospital setting for acute exacerbations of chronic obstructive pulmonary disease. *Cochrane Database Syst Rev*. 2020;1:Cd005534. doi: 10.1002/14651858.CD005534.pub3
27. Hodroge SS, Glenn M, Breyre A, Lee B, Aldridge NR, Sporer KA, Koenig KL, Gausche-Hill M, Salvucci AA, Rudnick EM, et al. Adult Patients with Respiratory Distress: Current Evidence-based Recommendations for Prehospital Care. *West J Emerg Med*. 2020;21:849-857. doi: 10.5811/westjem.2020.2.43896
28. Barnett A, Beasley R, Buchan C, Chien J, Farah CS, King G, McDonald CF, Miller B, Munsif M, Psirides A, et al. Thoracic Society of Australia and New Zealand Position Statement on Acute Oxygen Use in Adults: 'Swimming between the flags'. *Respirology*. 2022;27:262-276. doi: 10.1111/resp.14218

29. Gottlieb J, Capetian P, Hamsen U, Janssens U, Karagiannidis C, Kluge S, Nothacker M, Roiter S, Volk T, Worth H, et al. German S3 Guideline: Oxygen Therapy in the Acute Care of Adult Patients. *Respiration*. 2022;101:214-252. doi: 10.1159/000520294
30. Jensen AS, Valentin JB, Mulvad MG, Hagenau VH, Skaarup AH, Johnsen SP, Vaeggemose U, Gude MF. Standard vs. Targeted Oxygen Therapy Prehospitally for Chronic Obstructive Pulmonary Disease (STOP-COPD); study protocol for a randomised controlled trial. Research Square (Preprint). https://assets.researchsquare.com/files/rs-2760789/v1/6878e346-9818-471a-a140-051b8f6d41f1.pdf?c=1684531312. 2023. Accessed December 26.
31. Gude MF, Jensen AS. Standard vs Targeted Oxygen Therapy Prehospital for Chronic Obstructive Pulmonary Disease (STOP-COPD): NCT05703919. U.S. National Library of Medicine. https://classic.clinicaltrials.gov/ct2/show/NCT05703919. 2023. Accessed December 26.