Application Note
Predicted Normal Values Overview

C. Buess, November 2023

This document describes in detail which predicted normal values are implemented in ndd's products. For each publication, it lists the available predicted and lower limit of normal values, indicates the applicable age ranges, and describes special features such as ethnic correction.

1. Description of Tables for Predicted Values

The two tables of predicted values, shown at the end of this document, contain the following items:

Reference Name:	The reference name is used in the spirometry device or its software. The name consists of the main author of the study, optionally the study name or country in parentheses, and the latest year of publication.
Abbreviation:	Abbreviation for the study. In the tables, the abbreviation is used if parameters from another study are applied. Example: For most studies, 'Cherniak' (abbreviation CH) predicted values are used for the MVV parameter.
Age Range:	Age range used by the study. If the age range was extended beyond the study's range, the extended range is shown in parentheses.
Height Range:	Height range used by the study. Extended range is also listed in parentheses.
Use of Weight:	Specifies whether the patient's weight is used in the equations for the predicted values.
Ethnicity:	Ethnic groups that are supported by the study. A green field marked with 'o' means that the value is directly supported by the study. A green field without 'o' means that the predicted values are computed by the software using ethnic correction values.
Parameter:	In the parameter list, the following indicators are used:

o	The parameter is available in the study.
FVC, IVC	If 'FVC' is indicated in the field for VC, the study's FVC value is used for its parameter VC.
FEV1/FVC	FEV1/FVC is computed from the predicted values of FEV1 and FVC of the same source.
x	FEV1/FVC is used for FEV1/VC (or vice versa).
AB	The value is taken from the predicted source with the abbreviation AB.

LLN of Parameter:	This table lists the lower limits of normal (LLN) provided by the study. If the lower limit of normal values are not available as an equation, they are computed using the following formula: LLN = PredictedValue - 1.645 x SEE (Standard Error of Estimate). If there is no SEE value, the LLN is set to

	80% of the predicted value for absolute parameters (FVC, FEV1, etc.) and to 90% of the predicted value for relative parameters such as FEV1/FVC.
Lung Age:	Lung age is based on the measured FEV1 value of a patient. Using the predicted value equation for FEV1, lung age is determined by solving the equation for age: The input variables are the patient's demographics (gender, height) and the measured FEV1 value. The output variable constitutes the patient's lung age. Lung age, therefore, is the age at which the measured and the predicted FEV1 value of a patient are equal. The computation is based on the following publication: Spirometric Lung Age Estimation for Motivating Smoking Cessation. J.F. Morris, W. Temple. Prev Med 14, 655-662 (1985).

2. Extended Predicted Value Range

Published predicted spirometry values are based on a 'normal' population. In the publications, 'normal' values for spirometry parameters are derived from all the collected measurements. These 'normal' values can usually be computed using mathematical formulas. The formulas consider a patient's gender, age, height, and in some cases ethnicity and/or weight. The application of the studies' formulas is usually limited to the age and height ranges present in the 'normal' population of that study. When the caution message 'Extended predicted range used' is displayed on the device, this indicates that the formulas of the publication are being used, but the patient's age and/or height are above or below those of the 'normal' population that was used for the particular study. The formulas have been verified by ndd to be stable in the extrapolated range.

3. Ethnic Correction

Ethnic correction factors are only applied if the study does not directly support the selected ethnic group (see predicted overview table). The following two examples are used for clarification:

1. NHANES-III provides equations for predicted values for the ethnic groups Caucasian, African, and Hispanic. Ethnic correction factors defined in the software are therefore only used for the ethnic groups Asian and Other.
2. ERS predicted values only provide predicted values equations for the ethnic group Caucasian. In this case ethnic correction factors are used for all other ethnic groups.

The use of ethnic correction factors is always indicated on the report and in the software in the following way: NHANES-III × C, where C is the applied correction factor.

The following table lists which predicted values are affected by the ethnic correction factor:

Applied Correction	Predicted Value and LLN of Parameter
Multiplication by factor C	FVC, FIVC, FEV1, FEV3, FEV6, VC, FEV0.75, FEV0.5, MVV, VA, TLC, RV, IC, FRC
No correction	FEV1/FVC, FEV1/VC, FEV0.75/FVC, FEV0.5/FVC, FEV3/FVC, FEV1/FEV6, FEF25, FEF50, FEF75, FEF2575, PEF, PIF, MIF, DLCO, DLadj, DLCO/VA, RV/TLC, LCI

Note: Neither DLCO nor DLCO/VA are adapted using ethnic correction factors. The population data suggests that no ethnic correction is required for DLCO. Since the DLCO parameter is calculated from a VA derived from the tracer gas dilution, and VA directly effects DLCO in the calculation, any alteration in VA would also alter DLCO and DLCO/VA. Thus, in the predicted DLCO values, we need to predict DLCO to 'match' as closely to the normal/healthy populations as possible. Neither DLCO nor DLCO/VA require any ethnic correction.

4. Remarks Regarding Predicted Normal Values for Diffusion Capacity & Lung Volumes

1. The article by B. Make et al. compares different sources for predicted normal values and concludes that “the same subject may be classified as ‘normal’, ‘abnormal’ or ‘very abnormal’ depending on which equation is used”. This specifically applies to the predicted sources published by B. Burrows (very low values) and Ayers (no age dependency). See Make B, Miller A, Epler G, Gee JBL. Single breath diffusing capacity in the industrial setting. Chest 1982;82(3):351–356.
2. H.I. Goldman and M.R. Becklake’s predicted values are only used for TLCsb, RVsb, RV/TLCsb, and FRC.
3. Thompson et al.’s predicted values can only be applied down to the age of 45 years (see publication). In cooperation with the authors, it was decided to combine the predicted values published by Thompson with those of Miller for ages <45 years in ndd’s software.
4. VA and/or DLCO/VA predicted values are computed assuming VA = TLCsb – Vd, where Vd represents the anatomic dead space. Alternatively, TLCsb is computed by adding Vd to VA.
5. DLCO predicted values by Vazquez Garcia et al. (ALAT 2016) depend on the ‘altitude of residence’ of the patient. The appropriate value must be entered in the patient’s record stored on the device.
6. ERV predicted is computed by subtracting RV predicted from FRC predicted, if both RV and FRC predicted originate from the same source.
7. IC predicted is computed by subtracting FRC predicted from TLC predicted, if both FRC and TLC predicted originate from the same source.
8. Predicted values are taken from Hall et al. (Ha21, GLI reference values for static lung volumes).

5. Software Versions

Predicted Library	V1.31.0
EasyOne Connect	V3.9.5
EasyOne Air	V1.19.0

	Reference	Abbrev.	Publication List of Predicted Normal Values for Spirometry
North America, Canada	NHANES III (Hankinson)	NH	JL Hankinson, JR Odencrantz, KB Fedan. Spirometric Reference Values from a Sample of the General U.S. Population. Am J Respir Crit Care Med, Vol 159, p 179-187, 1999.
	Knudson 1983	KN83	Knudson, Ronald J, Michael Lebowitz, Holberg Catherine J., Burrows B. Changes in the Normal Maximal Expiratory Flow-Volume Curve with Aging. American Review of Respiratory Disease, Volume 127, p. 725-734, 1983.
	Knudson 1976	KN76	Knudson, Ronald J, R Slatin, M Lebowitz, B Burrows. The maximal Expiratory Flow-Volume Curve. American Review of Respiratory Disease, Volume 113, p. 587-600, 1976.
	Crapo	CR	Crapo RO, Morris AH, Gardner RM. Reference spirometric values using techniques and equipment that meets ATS recommendations. Am Rev Respir Dis Vol 123, p.659-664, 1981. Crapo RO, Morris AH, Clayton PD, Nixon CR. Lung Volumes in Healthy Nonsmoking Adults. Bull europ Physiopath resp, 419-425, 18, 1982.
	Morris	MO	Morris, James F., Koski, Arthur, Lavon Johnson. Spirometric Standards for Healthy Non-Smoking Adults. American Review of Respiratory Disease, Volume 10-3, p. 57-67, 1971 Morris, J.F. West J. Med (1976) 125:110-118.
	Hsu	HS	KH Hsu, PH Bartholomew, V Thompson, GSJ Hsieh. Ventilatory Functions of Normal children and Young Adults-Mexican-American, White, Black. I. Spirometry. J Pediatr Vol 95:14-23, 1979.
	Dockery, Wang (Harvard)	DO	X. Wang, D.W. Dockery, D. Wypij, M.E. Fay, B.G. Ferris. Pulmonary Function Between 6 and 18 Years of Age. Pediatr Pulmonol. 1993; 15:75-88.
	Polgar	PO	Polgar, Promadhat. Pulmonary Function Testing in Children: Techniques and Standards. W.B. Saunders Co., Philadelphia, 1971.
	Gutierrez (Canada)	CA	C. Gutierrez, RH Ghezzo, RT Abboud, et al. Reference values of pulmonary function tests for Canadian Caucasians. Can Respir J 2004; 11(6):414-424.
	Eigen	Ei	H Eigen, H Bieler, D Grant, K Christoph et al. Spirometric Pulmonary Function in Healthy Preschool Children. Am J Respir Crit Care Med Vol 163, 619-623, 2001.
	Cherniak	CH	RM Cherniak, MB Raber. Normal Standards for Ventilatory Function using an Automated Wedge Spirometer. American Review of Respiratory Disease. Vol 106, p.38-46, 1972.
Latin America	Pereira 1992	PE92	Carlos Alberto de Castro Pereira, Sueli da Penha Barreto, João Geraldo Simões, Francisco W.L. Pereira, José Gerson Gerstler, Joge Nakatani. Valores de referência para a espirometria em uma amostra da populacao brasileira adulta, Jornal de Pneumologia 18(1):10-22, maco de 1992.
	Pereira 2006, 2008	PE06	Pereira CAC et al. Espirometria em adultos 2006 and 2008. Remark: Spirometry predicted values 2006 and 2008 are identical.
	Pérez-Padilla (PLATINO)	PP06	<u>Age ≥ 40:</u> Pérez-Padilla R et al. Spirometric Reference Values in 5 Large Latin American Cities for Subjects Aged 40 Years or Over. Arch Bronconeumol 2006; 42(7):317-325. <u>Age < 40:</u> Since the PLATINO study only applies for age ≥ 40 years NHANES-III is selected for patients with age < 40 years.
	Pérez-Padilla (Mexico)	PP01	Pérez-Padilla R, Regalado-Pineda J, Vázquez-Garcia JC. Spirometry reproducibility and reference values in Mexican workers claiming disability. Salud Publica Mex 2001; 43:113-121.
	Pérez-Padilla (Mexico Ped.)	PP03	Pérez-Padilla R, Regalado-Pineda J et al. Spirometric Function in Children of Mexico-City Compared to Mexican-American Children. Pediatr Pulmonol 2003; 35:177-183.
	Chile 2010, 1997	CHI	<u>Age > 18:</u> MC Gutiérrez, GC Valdivia, LP Villarroel, GT Contreras et al. Nomogramas de ecuaciones de referencia espirométrica SER 2009. Rev Chil Enf Resir 2010; 26:9-15. <u>Age < 18:</u> MC Gutiérrez, FC Rioseco, AO Rojas, DZ Casanova. Reference spirometric values for the Chilean population at sea level. Rev Med Chile 1996; 124:1295-1306.
Europe / International	ERS (ECCS, EGKS)	ER	P.H. Quanjer. Lung Volumes and Forced Ventilatory Flows. Eur Respir J, Vol 6, Suppl 16, p. 5-40, 1993.
	Zapletal 1977	ZA	A. Zapletal, T. Paul, M. Samanek. Die Bedeutung heutiger Methoden der Lungenfunktionsdiagnostik zur Feststellung einer Obstruktion der Atemwege bei Kindern und Jugendlichen. Z. Erkrank. Atm.-Org., Volume 149, 343-371, 1977. A. Zapletal, M. Samanek, T. Paul. Upstream and total airway conductance in children and adolescents. Bull europ Physiopath resp 1982, 18, 31-37.
	Zapletal 2003	ZA03	A. Zapletal, J. Chalupová. Forced Expiratory Parameters in Healthy Preschool Children (3-6 Years of Age). Pediatr Pulmonol 2003; 35:200-207.
	Stanojevic 2009 (GLI)	ST	S. Stanojevic, A. Wade, TJ Cole, S Lum et al. Spirometry Centile Charts for Young Caucasian Children. Am J Respir Crit Care Med, Vol 180, pp 547-552, 2009. www.lungfunction.org.
	Quanjer 2012 (GLI)	QU	P.H. Quanjer, S. Stanojevic, T.J. Cole, X. Baur, G.L. Hall, B. Culver, P.L Enright, J.L. Hankinson, M.SM. Ip, J. Zheng, J. Stocks and the ERS Global Lung Function Initiative. Multi-Ethnic Reference Values For Spirometry For The 3-95 Year Age Range. The Global Lung Function 2012 Equations. ERJ Express, 10.1183/09031936.00080312.
	Bowerman, 2023 (Global GLI)	BO	Bowerman C, Bhakta NR, Brazzale D, et al. A Race-neutral Approach to the Interpretation of Lung Function Measurements. Am J Respir Crit Care Med 2023;207(6):768–774.
	Rosenthal	RO	M Rosenthal, SH Bain, D Cramer, P Helms, D Densison, A Bush, JO Warner. Lung function in white children aged 4 to 19 years: I – Spirometry. Thorax 1993; 48: 794-802.
	Austria 1988	FO88	G. Forche, K. Harnoncourt, E. Stadlober. Neue spirometrische Bezugswerte für Kinder, Jugendliche und Erwachsene. Öst. Ärzteztg. 43, 15-16, 1988.
	Austria 1994	FO94	G. Forche, H. Schinko. Skriptum Spirometrie der österreichischen Gesellschaft für Pneumologie. 1994.
	Sapaldia	SA	SAPALDIA team, O Brändli, CH. Schindler, N. Künzli, R. Keller, A.P. Perruchoud. Lung function in healthy never smoking adults: reference values and lower limits of normal of a Swiss population. Thorax 1996; 51:277-283.
	Spain (Roca, SEPAR)	BA	J. Roca et al. spirometric reference values for a Mediterranean population. Bull Eur Physiopathol Respir, 18:101-102, 1982. J Castellsagué, F Burgos, J Sunyer, JA Barberà, J Roca. Prediction equations for forced spirometry from European origin populations. Respir Med 1998 Mar; 92(3):401-7.
	Garcia-Rio (SEPAR 2013)	GR	F. Garcia-Rio, M. Calle, F. Burgos, P. Casan, F. del Campo, J.B. Galdiz, J. Giner, N. Gonzalez-Mangado, F. Ortega, L.P. Maestu. Normativa SEPAR. Espirometria. Arch Bronconeumol 2013; 49(9): 388-401.
	Vilozni 2005	VO	D Vilozni, A Barak, O Efrati, A Augarten, C Springer, Y Yahav, L Bentur. The role of computer games in measuring spirometry in healthy and 'asthmatic' preschool children. Chest 2005; 128: 1146-1155.
	Klement (Russia)	KL	R.F. Klement et al. Users instructions of main spirometry indexes predicted values formulas and tables. 1986.

	Reference	Abbrev.	Publication List of Predicted Normal Values for Spirometry
Scandinavia	Hedenström (Sweden)	HE	Female: H. Hedenström, P. Malmberg, K. Agarwal. Reference values for lung Function tests in females. Bull. Eur. Physiopathol. Respir. 21, p. 551-557, 1985. Male: H. Hedenström, P. Malmberg, H.V. Fridriksson. Reference values for lung function tests in men. Upsala J. Med. Sci., 91:299-310, 1986.
	Gulsvik (Norway)	GU	A. Gulsvik. Spirometri (Korrespondanser). Tidsskr Nor Loegeforen nr. 31, 105:2240-2, 1985.
	Berglund, Birath (Sweden)	BE	E. Berglund, G. Birath, J. Bjure, G. Grimby, I. Kjellmer, L. Sandqvist, B. Söderholm. Spirometric Studies in Normal Subjects. Acta Medica Scandinavica, Vol. 173, fasc. 2, 185-192, 1963. FEF2575, MVV: G. Birath, I. Kjellmer, L. Sandqvist. Spirometric Studies in Normal Subjects. Acta Medica Scandinavica, Vol. 173, fasc. 2, 193-198, 1963.
	Langhammer (Norway)	LA	A. Langhammer, R. Johnson, A. Gulsvik, T.L. Holmen, L. Bjermer. Forced spirometry reference values for Norwegian adults. Eur Respir J 2001; 18:770-779.
	Finnish	FI	Adult: The Scandinavian Journal of Clinical & Laboratory Investigation, Vol. 42 - Suppl 159, 1982. Pediatric: Suomen Lääkärilethi, Vol. 53, 395-402, 1998.
	Nystad	NY	W Nystad, SO Samuelson, P Nafstad, E Edvardsen, T Stensrud, JJK Joakkola. Feasibility of measuring lung function in preschool children. Thorax 2002; 57: 1021-1027.
	Kainu 2016 (Finland)	KA	A. Kainu, K.L. Timonen, J. Toikka, B. Qaiser, J. Pitkäniemi, J. T. Kotaniemi, A. Lindqvist, E. Vanninen, E. Länsimies and A.R.A. Sovijärvi. Reference values of spirometry for Finnish adults. Clin Physiol Funct Imaging (2016) 36, pp346–358.
Aust-ralia	Hibbert	HI	Marienne E. Hibbert, M App SCI, Anna Lannigan, RN, Louis I. Landau, MD, Peter D. Phelan, MD. Lung Function Values From a Longitudinal Study of Healthy Children Adolescents, Pediatric Pulmonology 7:101-109 (1989).
	Gore, Crockett	GO	CJ Gore, AJ Crockett, DG Pederson, ML Booth, A Bauman, N Owen. Spirometric standards for healthy adult lifetime nonsmokers in Australia. Eur Respir J, 1995, 8, 773-782.
Africa, Asia	Chhabra (India)	CHH	S.K. Chhabra, R. Kumar, U. Gupta, M. Rahman, D.J. Dash. Prediction Equations for Spirometry in Adults from Northern India. Indian J Chest Dis Allied Sci 2014; 56:221-225.
	Dejsomritrutai (Thailand)	DE	Dejsomritrutai W, Nana A, Maranetra N, et al. Reference spirometric values for healthy lifetime nonsmokers in Thailand. J Med Assoc Thai 2000; 83: 457-466.
	Ethiopia	ET	Y.A. Mengesha Y. Mekonnen. Spirometric lung function tests in normal non-smoking Ethiopian men and women. Thorax 1985; 40:465-468.
	Indonesia	IN	Hasil Penelitian Tim Pneumobile Project Indonesia 1992.
	Ip (China, Hongkong)	IP	M.S.M. Ip et al. Updated Spirometric Reference Values for Adult Chinese in Hong Kong and Implications on Clinical Utilization. CHEST 2006 ; 129 : 384-392 M.S.M. Ip et al. Lung Function Reference Values in Chinese Children and Adolescents in Hong Kong. Am J Respir Crit Care Med Vol 162, 2000, 424-429.
	JRS 2001	JR01	日本人のスパイログラムと動脈血液ガス分圧基準値 日本呼吸器学会肺生理専門委員会２００１年４月
	JRS 2014	JR14	M. Kubota et al. Reference values for spirometry, including vital capacity, in Japanese adults with LMS method and compared with previous values. Respiratory investigation 52 (2014) 242-250.

	Reference	Abbrev.	Publication List of Predicted Normal Values for Lung Volumes, Diffusion Capacity and LCI
North America	Ayers	Ay	Ayers LN, Ginsberg ML, Fein J, Wasserman K. Diffusing capacity and interpretation of diffusing defects. West J Med 1975; 123:255-264.
	Burrows	Bu	Burrows BJ, Kasik JE, Niden AH, Barclay WR. Clinical usefulness of the single-breath pulmonary diffusing capacity test. Am Rev Respir Dis 1961; 84:798-806.
	Cotes	Co	Cotes JE. Lung function, 4th ed. Oxford: Blackwell Scientific, 1979.
	Crapo	Cr	Crapo RO, Morris AH. Standardized single breath normal values for carbon monoxide diffusing capacity. Am Rev Respir Dis 1981; 123:185-189.
	Goldman & Becklake	GB	Goldman HI, Becklake MR. Respiratory function tests; normal values at median altitudes and the prediction of normal results. Am Rev Tuberc. 1959 Apr;79(4):457-67.
	Knudson	Kn	Knudson RJ, Kaltenbom WT, Knudson DE, Burrows B. The single-breath carbon monoxide diffusing capacity: Reference equations derived from a healthy nonsmoking population and effects of hematocrit. Am Rev Respir Dis 1987; 135: 805–811.
	McGrath & Thompson	MT	McGrath MW, Thompson ML. The effect of age, body size and lung volume change on alveolar-capillary permeability and diffusing capacity in man. J Physiol 1959; 146:572-582.
	Miller	Mi	Miller A, Thornton JC, Warshaw R, Anderson H, Teirstein AS, Selikoff IJ. Single breath diffusing capacity in a representative sample of the population of Michigan, a large industrial state. Am Rev Respir Dis 1983; 127:270-277.
	NHANES	NH	LM Neas, J Schwartz. The determinants of pulmonary diffusing capacity in a national sample of U.S. adults. Am J Respir Crit Care Med, 153(2), 1996, 656-664.
	Gutierrez (Canada)	CA	C Gutierrez, RH Ghezzo, RT Abboud, et al. Reference values of pulmonary function tests for Canadian Caucasians. Can Respir J 2004; 11(6):414-424.
	Polgar	Po	Polgar, Promadhat. Pulmonary Function Testing in Children: Techniques and Standards. W.B. Saunders Co., Philadelphia, 1971.
Europe Scandinavia	ERS	ER	P.H. Quanjer. Lung Volumes and Forced Ventilatory Flows. Eur Respir J, Vol 6, Suppl 16, p. 5-40, 1993.
	Zapletal	Za	A. Zapletal, T. Paul, M. Samanek. Die Bedeutung heutiger Methoden der Lungenfunktionsdiagnostik zur Feststellung einer Obstruktion der Atemwege bei Kindern und Jugendlichen. Z. Erkrank. Atm.-Org., Volume 149, 343-371, 1977.
	Roca	Ro	Roca J, Rodriguez-Roisin R, Cobo E, Burgos F, Perez J, Clausen JL. Single breath carbon monoxide diffusing capacity prediction equations from a Mediterranean population. Am Rev Respir Dis 1990; 141:1026-1032. Roca J, Burgos F, Barbera JA, Sunyer J, Rodriguez-Roisin R, Castellsague J, Snchis J, Antoo JM, Casan P, Clausen JL. Prediction euqations for plethismographic lung volumes. Respir Med, 1998, 92, 454-460.
	Hedenström	He	Female: H. Hedenström, P. Malmberg, K. Agarwal. Reference values for lung Function tests in females. Bull. Eur. Physiopathol. Respir. 21, p. 551-557, 1985. Male: H. Hedenström, P. Malmberg, H.V. Fridriksson. Reference values for lung function tests in men. Upsala J. Med. Sci., 91:299-310, 1986.
	Gulsvik	Gu	Gulsvik A, Bakke P, Humerfelt S, Omenaas E, Tosteson T, Weiss ST, Speizer FE. Single breath transfer factor for carbon monoxide in an asymptomatic population of never smokers. Thorax 1992; 47:167-173.
	Verbanck	SV	S Verbanck, BR Thompson et al. Ventilation heterogeneity in the acinar and conductive zones of the normal ageing lung. Thorax 2012; 67:789-795.
	Klement (Russia)	KL	R.F. Klement et al. Users instructions of main spirometry indexes predicted values formulas and tables. 1986.
	Stanojevic (GLI)	ST17	S. Stanojevic at al. Official ERS technical standards: Global Lung Function Initiative Reference Values for the carbon monoxide transfer factor for Caucasians. Eur Respir J 2017: 50: 17000 10. Including correction from the year 2020, see https://erj.ersjournals.com/content/50/3/1700010.short
	Hall (GLI)	Ha21	Hall GL, Filipow N, Ruppel G, et al. Hall-2021 (GLI), Official ERS technical standard: Global Lung Function Initiative reference values for static lung volumes in individuals of European ancestry. Eur Respir J. 2021;57(3):2000289. doi:10.1183/13993003.00289-2020.
Other	Pereira 2008	PE08	Neder JA et al. Volumes pulmonares, diusão de CO, VVM e força muscular.
	Thompson	Th	Thompson BR, Johns DP, et al. Predicted equations for single breath diffusing capacity (Tlco) in a middle aged caucasian population. Thorax 2008; 63:889-893.
	Ip (China Hong Kong)	Ip	M.S.M. Ip et al. Reference values of diffusing capacity of non-smoking Chinese in Hong Kong. Respirology (2007) 12, 599-606.
	Kim	KI	Kim YJ, Hall GL, Christoph K, Tabbey R, Yu Z, Tepper RS, Eigen H. Pulmonary diffusing capacity in healthy caucasian children. Ped Pul 47:469-475 (2012).
	Vazquez Garcia	VG	Vazquez-Garcia JC, Perez-Padilla R, Lopez V, Muino A, Schönfeld P, Jardim J, Montes de Oca M, Casas A. Normal values of inspiratory capacity and carbon monoxide uptake in the lung in Latin America. ALAT, 2016.
	Gochicoa, 2019 (Mexico)	GO	Laura Gochicoa-Rangel, Rodrigo Del-Rio-Hidalgo, Maria René Alvarez-Arroyo, David Martınez-Briseño, Uri Mora-Romero, Luisa Martinez-Valdeavellano, Johanna Navarrete-Rivera, Luis Rodriguez-Moreno, Selene Guerrero-Zuñiga, Rosario Fernandez-Plata, Gabriela Cantu-Gonzalez, Silvia Cid-Juarez, Cecilia Garcia-Sancho, Ireri Thirion-Romero, Monica Silva-Ceron, Rogelio Pérez-Padilla, and Luis Torre-Bouscoulet. Diffusing Capacity of the Lung for Carbon Monoxide in Mexican/Latino Children. Ann Am Thorac Soc Vol 16, No 2, pp 240–247, Feb 2019.

Predicted Normal Values for Spirometry

Region	Reference Name (used in User Interface)	Abbreviation	Age Range [yr]	Height Range [cm]	Use of Weight	Ethnicity: Caucasian	African	Hispanic	Asian	Other	NE-Asian	SE-Asian
North America	Hankinson (NHANES III), 1999	NH	8..80 (6..90)	110..195 (110..210)	no	o	o	o			As	As
	Knudson, 1983	KN83	6..85	107..183/196 (107..210)	no	o					As	As
	Knudson, 1976	KN76	8..85	110..200 (110..210)	no	o					As	As
	Crapo, 1981	CR	15..91	146..195 (146..210)	no	o					As	As
	Morris, 1971	MO	19..90	142..203 (142..210)	no	o					As	As
	Hsu, 1979	HS	7..20 (4..20)	110..195 (93..210)	no	o	o	o			As	As
	Dockery (Harvard), 1993	DO	6..18	115..185 (115..210)	no	o	o				As	As
	Polgar, 1971	PO	4..18	109..170 (90..210)	no	o					As	As
	Gutierrez (Canada), 2004	CA	5..80 (5..90)	n/a	no	o					As	As
	Eigen, 2001	EI	3..6	85..135	no	o					As	As
Latin America	Pereira, 1992	PE92	20..78 (20..)	136..182 (90..220)	no	o	o				As	As
	Pereira, 2006/2008	PE06	6..86	n/a	yes	o					As	As
	Pérez-Padilla (PLATINO), 2006	PP06	40..90 (40..100)	n/a	no			o				
	Pérez Padilla (Mexico), 2001	PP01	20..65 (20..80)	n/a	no			o				
	Pérez Padilla (Mexico), 2003	PP03	8..20 (6..20)	n/a	yes			o				
	Chile, 2010/1997	CHI	5..94	100..190	no	o		o				
Europe / International	ERS (ECCS/EGKS), 1993	ER	18..70 (18..90)	145..195 (145..210)	no	o					As	As
	Zapletal, 1977	ZA	6..17 (4..17)	115..180 (93..210)	no	o					As	As
	Zapletal, 2003	ZA03	3..6	90..130	no	o					As	As
	Stanojevic (GLI), 2009	ST	3..80	n/a	no	o					As	As
	Quanjer (GLI), 2012	QU	3..95	50..250	no	o	o	Ot	Ot	o	o	o
	Bowerman (Gloabl GLI), 2023	BOex	3..95	50..250	no	o	o	o	o	o	o	o
	Rosenthal, 1993	RO	4..19	110-185	no	o					As	As
	Forche (Austria), 1988	FO88	7..76 (7..90)	110..200 (110..210)	no	o					As	As
	Forche (Austria), 1994	FO94	5..90	109..200	yes	o					As	As
	Brändli (Sapaldia, Swiss), 1996	SA	18..60 (18..90)	n/a	no	o					As	As
	Roca (Spain, Separ), 1982	BA	6..70 (6..90)	110-200 (110..210)	yes	o					As	As
	Garcia-Rio (Separ), 2013	GR	6..85	110-200 (110..210)	yes	o					As	As
	Vilozni, 2005	VI	2..7	85..130	no	o					As	As
	Falaschetti, 2004	FA	16..95	n/a	no	o					As	As
	Klement (Russia)	KL	18..70 (18..80)	n/a	no	o					As	As
Europe Scandinavia	Hedenström (Sweden), 1985/1986	HE	20..70 (18..90)	150..195 (150..210)	yes	o					As	As
	Gulsvik (Norway), 1985	GU	20..70 (18..90)	150..190 (150..210)	no	o					As	As
	Berglund, Birath (Sweden), 1963	BE	20..70 (18..90)	154..191 (154..210)	no	o					As	As
	Langhammer (Norway), 2001	LA	20..80 (20..90)	n/a	no	o					As	As
	Finnish, 1982/1998	FI	6..90	115..180 (90..220)	no	o					As	As
	Nystad, 2002	NO	3..7	85..130	yes	o					As	As
	Koillinen. 1998	KOI	6-17	100-190	no	o					As	As
	Kainu, 2016 (Finland)	KAI	18..83	n/a	no	o					As	As
Australia	Hibbert, 1989	HI	8..19 (6..19)	120..190 (90..220)	no	o					As	As
	Gore, Crockett, 1995	GO	18..78 (18..)	145..195 (90..220)	no	o					As	As
Africa, Asia	Chhabra (India), 2014	Ch	18..70 (18..85)	140..195 (120..210)	yes				o		As	As
	Dejsomritrutai (Thailand), 2000	DJ	18-90	n/a	no				o		As	As
	Mengesha (Ethiopia), 1985	ET	20..90	n/a	no		o					
	Indonesia, 1992	In	13..85	110..190	no				o		As	As
	Ip (China, Hongkong), 2006	IP1	7..17	110..190 (100..200)	no				o		As	As
	Ip (China, Hongkong), 2000	IP2	18..80 (18..90)	n/a	no				o		As	As
	JRS, 2001	JR	18..92 (18..)	90..220	no				o		As	As
	JRS, 2014	JR14	17..95	n/a	no				o		As	As

Predicted Value of Parameter

Reference Name	FVC	FIVC	VC	FEV1	FEV1 / FVC	FEV1 / VC	FEV0.75	FEV0.75/FVC	FEV0.5	FEV3	FEV6	FEV3 / FEV6	FEV1 / FEV6	FEF25(MEF75)	FEF50(MEF50)	FEF75(MEF25)	FEF2575(MMEF)	PEF	PIF	MIF 50	MVV	Lung Age
Hankinson (NHANES III), 1999	o	FVC	FVC	o	o	x					o		o				o	o			CH	o
Knudson, 1983	o	FVC	FVC	o	o	x				o 76					o	o	o	o 76			CH	o
Knudson, 1976	o	FVC	FVC	o	o	x				o							o	o			CH	o
Crapo, 1981	o	FVC	FVC	o	o	x				o		o					o				CH	o
Morris, 1971	o	FVC	FVC	o	o 76	x											o				CH	o
Hsu, 1979	o	FVC	FVC	o	FEV1 /FVC	x											o	o			CH	o
Dockery (Harvard), 1993	o	FVC	FVC	o	o	x											o				CH	o
Polgar, 1971	o	FVC	FVC	o	o	x			o	o							o	o			o	
Gutierrez (Canada), 2004	o	FVC	o	o	o	x									o	o	NH	NH	o	o	o	o
Eigen, 2001	o	FVC	FVC	o	o	x											o	o				
Pereira, 1992	o	FVC	FVC	o	o	x											o	o			CH	
Pereira, 2006/2008	o	FVC	FVC	o	o	x									o	o	o	o			o	
Pérez-Padilla (PLATINO), 2006	o	FVC	FVC	o	o	x					o		o				o	o				
Pérez Padilla (Mexico), 2001	o	FVC	FVC	o	o	x								o	o		o	o				
Pérez Padilla (Mexico), 2003	o	FVC	FVC	o	o	x								o			o	o				
Chile, 2010/1997	o	FVC	FVC	o	o	x											o				o	
ERS (ECCS/EGKS), 1993	o	FVC	IVC	o	o	x								o	o	o	o	o			CH	o
Zapletal, 1977	o	FVC	o	o	o	x								o	o	o	o	o			CH	
Zapletal, 2003	o	FVC	FVC	o	o	x								o	o	o		o			CH	
Stanojevic (GLI), 2009	o	FVC	FVC	o	o	x											o				CH	
Quanjer (GLI), 2012	o	FVC	FVC	o	o	x	o	o								o	o				CH	
Bowerman (Gloabl GLI), 2023	o	FVC	FVC	o	o	x										QU	QU	NH			CH	
Rosenthal, 1993	o	FVC	o	o	o	x									o	o		o	o		CH	
Forche (Austria), 1988	o	FVC	FVC	o	o	x								ER	ER	ER	ER	ER			o	
Forche (Austria), 1994	o	FVC	FVC	o	o	x								o	o	o		o			CH	
Brändli (Sapaldia, Swiss), 1996	o	FVC	FVC	o	o	x								o	o	o	o	o			CH	
Roca (Spain, Separ), 1982	o	FVC	FVC	o	FEV1 /FVC	x									o	o	o	o			CH	
Garcia-Rio (Separ), 2013	o	FVC	FVC	o	o	x											o	o			CH	
Vilozni, 2005	o	FVC	FVC	o	o	x			o						o	o	o	o				
Falaschetti, 2004	o	FVC	FVC	o	o	x															CH	
Klement (Russia)	o	FVC	o	o	o	x								o	o	o	o	o			CH	
Hedenström (Sweden), 1985/1986	o	FVC	o	o	x	o								o	o	o		o			o	o
Gulsvik (Norway), 1985	VC	VC	o	o	o	x											o				CH	o
Berglund, Birath (Sweden), 1963	VC	VC	o	o	o	x											o				o	o
Langhammer (Norway), 2001	o	FVC	FVC	o	o	x											o	o			CH	
Finnish, 1982/1998	o	FVC	o	o	o	o			o						o	o		o	o		CH	
Nystad, 2002	o	FVC	o	o					o									o				
Koillinen. 1998	o	o	FVC FIVC	o	o	x			o						o			o				
Kainu, 2016 (Finland)	o	FVC	FVC	o	o	x					o		o	o	o	o	o	o			CH	
Hibbert, 1989	VC	VC	o	o	FEV1 /FVC	x								o	o	o	o				CH	
Gore, Crockett, 1995	o	FVC	FVC	o	o	x											o	o			CH	
Chhabra (India), 2014	o	FVC	FVC	o	o	o									o	o	o	o				
Dejsomritrutai (Thailand), 2000	o	FVC	FVC	o	o	x											o	o				
Mengesha (Ethiopia), 1985	o	FVC	FVC	o	o	x												o				
Indonesia, 1992	o	FVC	FVC	o	o	x												o				
Ip (China, Hongkong), 2006	o	FVC	FVC	o											o							
Ip (China, Hongkong), 2000	o	FVC	FVC	o	o	x											o					
JRS, 2001	o	FVC	o	o	o	o			o	o		o		o	o	o	o	o				o
JRS, 2014	o	FVC	o	o	o	x																

Lower Limit of Normal (LLN) Value of Parameter

Reference Name	FVC	FIVC	VC	FEV1	FEV1 / FVC	FEV1 / IVC	FEV0.75	FEV0.75/FVC	FEV0.5	FEV3	FEV6	FEV3 / FVC	FEV1 / FEV6	FEF25	FEF50	FEF75	FEF25-75	PEF	PIF	MIF 50	MVV
Hankinson (NHANES III), 1999	o	FVC	FVC	o	o	x					o		o				o	o			
Knudson, 1983	o	FVC	FVC	o	o	x				-					o	o	o	-			
Knudson, 1976	o	FVC	FVC	o	o	x															
Crapo, 1981	o	FVC	FVC	o	o	x				o		o					o				
Morris, 1971	o	FVC	FVC	o	o	x											o				
Hsu, 1979	o	FVC	FVC	o													o	o			
Dockery (Harvard), 1993	o	FVC	FVC	o	o	x											o				
Polgar, 1971	o		FVC	o	o	x															
Gutierrez (Canada), 2004	o	FVC	o	o	o	x									o	o	NH	NH	o	o	o
Eigen, 2001	o	FVC	FVC	o	o	x											o	o			
Pereira, 1992	o	FVC	FVC	o	o	x											o	o			
Pereira, 2006/2008	o	FVC	FVC	o	o	x									o	o	o	o			o
Pérez-Padilla (PLATINO), 2006	o	FVC	FVC	o	o	x					o		o				o	o			
Pérez Padilla (Mexico), 2001	o	FVC	FVC	o	o	x								o	o		o	o			
Pérez Padilla (Mexico), 2003	o	FVC	FVC	o	o	x								o			o	o			
Chile, 2010/1997	o	FVC	FVC	o	o	x											o				o
ERS (ECCS/EGKS), 1993	o	FVC	IVC	o	o	x								o	o	o	o	o			
Zapletal, 1977	o	FVC	o	o	o	x								o	o	o	o	o			
Zapletal, 2003	o	FVC	FVC	o	o	x								o	o	o		o			
Stanojevic (GLI), 2009	o	FVC	FVC	o	o	x											o				
Quanjer (GLI), 2012	o	FVC	FVC	o	o	x	o	o								o	o				
Bowerman (Gloabl GLI), 2023	o	FVC	FVC	o	o	x										QU	QU	NH			
Rosenthal, 1993	o	FVC	o	o	o	x									o	o		o	o		
Forche (Austria), 1988	o	FVC	FVC	o	o	x								ER	ER	ER	ER	ER			o
Forche (Austria), 1994	o	FVC	FVC	o	o	x								o	o	o		o			
Brändli (Sapaldia, Swiss), 1996	o	FVC	FVC	o	o	x								o	o	o	o	o			
Roca (Spain, Separ), 1982	o	FVC	FVC	o											o	o	o	o			
Garcia-Rio (Separ), 2013	o	FVC	FVC	o	o	x											o	o			
Vilozni, 2005	o	FVC	FVC	o	o	x			o						o		o	o			
Falaschetti, 2004	o	FVC	FVC	o	o	x															
Klement (Russia)	o	FVC	o	o	o	x								o	o	o	o	o			
Hedenström (Sweden), 1985/1986	o	FVC	o	o	x	o								o	o	o		o			o
Gulsvik (Norway), 1985	VC	VC	o	o	o	x											o				
Berglund, Birath (Sweden), 1963	VC	VC	o	o	o	x											o				o
Langhammer (Norway), 2001	o	FVC	FVC	o	o	x											o	o			
Finnish, 1982/1998	o	FVC	o	o	o	o			o						o	o		o	o		
Nystad, 2002	o	FVC	o	o					o									o			
Koillinen. 1998	o	FVC	o	o					o									o			
Kainu, 2016 (Finland)	o	FVC	FVC	o	o	x					o		o	o	o	o	o	o			
Hibbert, 1989	VC	VC	o	o		x								o	o	o	o				
Gore, Crockett, 1995	o	FVC	FVC	o	o	x											o	o			
Chhabra (India), 2014	o	FVC	FVC	o	o	o									o	o	o	o			
Dejsomritrutai (Thailand), 2000	o	FVC	FVC	o	o	x											o	o			
Mengesha (Ethiopia), 1985	o	FVC	FVC	o														o			
Indonesia, 1992	o	FVC	FVC	o	o	x												o			
Ip (China, Hongkong), 2006	o	FVC	FVC	o											o						
Ip (China, Hongkong), 2000	o	FVC	FVC	o	o	x											o				
JRS, 2001	o	FVC	o	o	o	o									o	o					
JRS, 2014	o	FVC	o	o	o	x															

Region	Predicted Normal Values for Lung Volumes, DLCO and LCI — Reference	Year of Publication	Abbreviation	Age Range [yr]	Height Range [cm]	Use of Weight	Ethnicity: Caucasian	African	Hispanic	Asian	Other	NE-Asian	SE-Asian
North America	**Ayers, 1975** (see 1)	1975	Ay	5..76 (5..90)	n/a	unused	o					As	As
North America	**Burrows, 1961** (see 1)	1961	Bu	20..90	n/a	used	o					As	As
North America	**Crapo, 1981/1982**	1981 1982	Cr	16..91	146..194	unused	o					As	As
North America	**Goldman & Becklake, 1958** (see 2)	1958	GB	20..100	n/a	used for FRC	o					As	As
North America	**Knudson, 1987**	1987	Kn	9..90	n/a	unused	o					As	As
North America	**McGrath & Thompson, 1959**	1959	MT	15..75	n/a	unused	o					As	As
North America	**Miller, 1983**	1983	Mi	20..70 (20..80)	n/a	unused	o					As	As
North America	**Gutierrez (Canada), 2004**	2004	CA	20..80	n/a	unused	o					As	As
North America	**Neas (NHANES), 1996**	1996	NH	20..100	n/a	unused	o	o				As	As
North America	**Polgar, 1971**	1971	Po	5..19	n/a	unused	o					As	As
Europe Scandinavia	**ERS (ECCS/EGKS), 1993**	1993	ER	18..70 (18..90)	n/a	unused	o					As	As
Europe Scandinavia	**Zapletal, 1977**	1977	Za	6..17	n/a	unused	o					As	As
Europe Scandinavia	**Roca, 1990/1998**	1990 1998	Ro	17..70 (17..100)	n/a	used	o					As	As
Europe Scandinavia	**Hedenström 1985/1986**	1985 1986	He	20..70 (18..90)	150..195 (150..210)	used	o					As	As
Europe Scandinavia	**Gulsvik, 1992**	1992	Gu	18..73 (18..90)	n/a	unused	o					As	As
Europe Scandinavia	**Klement (Russia), 1986**	1986	KL	18..70 (18..80)	n/a	unused	o					As	As
Europe Scandinavia	**Stanojevic, 2017, Hall 2021 (GLI)**	2017 2021	St17 Ha21	5..90, 5..80	n/a	unused	o					As	As
Other	**Pereira, 2008**	2008	PE08	20..80	n/a	unused	o					As	As
Other	**Vazquez-Garcia (ALAT), 2016**	2016	VG	20..85	n/a	used			o			As	As
Other	**Thompson, 2008** (see 3)	2008	Th	45..72	m: 157..195 f: 141-184	m: 55-109 f: 47-92	o					As	As
Other	**Kim, 2012**	2012	Ki	5..19	100..200	unused	o					As	As
Other	**Gochicoa, 2019 (Mexico)**	2019	Go	4..22	60..200	used 5..150			o				
Other	**Chhabra (India), 2015**	2015	CHH	18..85	120..210	used				o		As	As
Other	**Ip (China Hongkong), 2007**	2007	Ip	18..80 (18..90)	130..190 (110..210)	used				o		As	As
Other	**JRS (Japan), 2001**	2001	JR01	18..92 (18..)	90..220	used				o		As	As

Predicted Value of Parameter

Reference	DLCO	DLCO/VA	VA	TLC_{sb}	RV_{sb}	RV_{sb}/TLC_{sb}	TLC_{mb}	RV_{mb}	RV_{mb}/TLC_{mb}	FRC_{mb}	LCI	IC	ERV
Ayers, 1975	o	o	GB	GB	GB	GB	GB	GB	GB	GB	SV	o[7]	o[6]
Burrows, 1961	o	o[4]	GB	GB	GB	GB	GB	GB	GB	GB	SV	o[7]	o[6]
Crapo, 1981/1982	o	o	o[4]	o	o	o	o	o	o	o	SV	o[7]	o[6]
Goldman & Becklake, 1958			o[4]	o	o	o	o	o	o	o	SV	o[7]	o[6]
Knudson, 1987	o	o	o	o[4]	GB	GB	o[4]	GB	GB	GB	SV		o[6]
McGrath & Thompson, 1959	o	o	GB	GB	GB	GB	GB	GB	GB	GB	SV	o[7]	o[6]
Miller, 1983	o	o[4]	o[4]	o	GB	GB	o	GB	GB	GB	SV		o[6]
Gutierrez (Canada), 2004	o	o	o	o	o	o	o	o	o	o	SV	o	o[6]
Neas (NHANES), 1996	o	o[4]	GB	GB	GB	GB	GB	GB	GB	GB	SV	o[7]	o[6]
Polgar, 1971	o	o[4]	o[4]	o	o		o	o			SV		
ERS (ECCS/EGKS), 1993	o	o[4]	o[4]	o	o	o	o	o	o	o	SV	o[7]	o[6]
Zapletal, 1977	o	o[4]	o[4]	o	o	o	o	o	o	o	SV	o[7]	o[6]
Roca, 1990/1998	o	o	o	o	o	o	o	o	o	o	SV	o	o[6]
Hedenström 1985/1986	o	o[4]	o[4]	o	o	o	o	o	o	o	SV	o[7]	o[6]
Gulsvik, 1992	o	o	o	o[4]	ER	ER	o[4]	ER	ER	ER	SV		o[6]
Klement (Russia), 1986	ER		o[4]	o	o	o	o	o	o	o	SV	o[7]	o[6]
Stanojevic, 2017, Hall 2021 (GLI)	o	o	o	o[4]			o[8]	o[8]	o[8]	o[8]	SV	o[8]	o[8]
Pereira, 2008	o	o[4]	o[4]	o	o	RV / TLC	o	o	RV / TLC	o	SV	o	o[6]
Vazquez-Garcia (ALAT), 2016	o	o	o	o	o	o	o	o	o	o	SV	o[7]	o[6]
Thompson, 2008	o	o	o	o[4]	GB	GB	o[4]	GB	GB	GB	SV		o[6]
Kim, 2012	o	o	o	o[4]			o[4]				SV		
Gochicoa, 2019 (Mexico)	o	o[4]	o	o	o		o	o			SV		
Chhabra (India), 2015	o		o	o[4]			o[4]				SV		
Ip (China Hongkong), 2007	o	o	o[4]	o[4]			o[4]				SV		
JRS (Japan), 2001	o	o	o	o[4]	o	o	o[4]	o	o	o	SV	o[7]	o[6]

LLN Value of Parameter

Reference	DLCO	DLCO/VA	VA	TLC	RV	RV/TLC	TLC_{mb}	RV_{mb}	RV_{mb}/TLC_{mb}	FRC	IC	ERV
Ayers, 1975	o		GB	GB	GB	GB	GB	GB	GB	GB		
Burrows, 1961	o		GB	GB	GB	GB	GB	GB	GB	GB		
Crapo, 1981/1982	o	o	o[4]	o	o	o	o	o	o	o		
Goldman & Becklake, 1958			o[4]	o	o	o	o	o	o	o		
Knudson, 1987	o	o	o	o[4]	GB	GB	o[4]	GB	GB	GB		
McGrath & Thompson, 1959	o	o	GB	GB	GB	GB	GB	GB	GB	GB		
Miller, 1983	o	o[4]	o[4]	o	GB	GB	o	GB	GB	GB		
Gutierrez (Canada), 2004	o	o	o	o	o	o	o	o	o	o	o	
Neas (NHANES), 1996	o		GB	GB	GB	GB	GB	GB	GB	GB		
Polgar, 1971	o											
ERS (ECCS/EGKS), 1993	o		o[4]	o	o	o	o	o	o	o		
Zapletal, 1977	o		o[4]	o	o	o	o	o	o	o		
Roca, 1990/1998	o	o	o	o	o	o	o	o	o	o	o	
Hedenström 1985/1986	o		o[4]	o	o	o	o	o	o	o		
Gulsvik, 1992	o	o	o	o[4]	ER	ER	o[4]	ER	ER	ER		
Klement (Russia), 1986	ER		o[4]	o	o	o	o	o	o	o		
Stanojevic, 2017, Hall 2021 (GLI)	o	o	o	o[4]			o[8]	o[8]	o[8]	o[8]	o[8]	o[8]
Pereira, 2008	o											
Vazquez-Garcia (ALAT), 2016	o	o	o	o		o	o		o			
Thompson, 2008	o	o	o	o[4]	GB	GB	o[4]	GB	GB	GB		
Kim, 2012	o	o	o	o[4]			o[4]					
Gochicoa, 2019 (Mexico)	o	o[4]	o	o	o		o	o				
Chhabra (India), 2015	o		o	o[4]			o[4]					
Ip (China Hongkong), 2007	o	o										
JRS (Japan), 2001												