Information is Different Now That You're a Doctor

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References:

Abramson, J., Adler, J., Dunger, J., Evans, R., Green, T., Pritzel, A., Ronneberger, O., Willmore, L., Ballard, A.J., Bambrick, J., Bodenstein, S.W., Evans, D.A., Hung, C.-C., O'Neill, M., Reiman, D., Tunyasuvunakool, K., Wu, Z., Žemgulytė, A., Arvaniti, E., Beattie, C., Bertolli, O., Bridgland, A., Cherepanov, A., Congreve, M., Cowen-Rivers, A.I., Cowie, A., Figurnov, M., Fuchs, F.B., Gladman, H., Jain, R., Khan, Y.A., Low, C.M.R., Perlin, K., Potapenko, A., Savy, P., Singh, S., Stecula, A., Thillaisundaram, A., Tong, C., Yakneen, S., Zhong, E.D., Zielinski, M., Žídek, A., Bapst, V., Kohli, P., Jaderberg, M., Hassabis, D., Jumper, J.M., 2024. Accurate structure prediction of biomolecular interactions with AlphaFold 3. Nature. https://doi.org/10.1038/s41586-024-07487-w

Ali, S.R., Dobbs, T.D., Hutchings, H.A., Whitaker, I.S., 2023. Using ChatGPT to write patient clinic letters. Lancet Digit Health 5, e179–e181. https://doi.org/10.1016/S2589-7500(23)00048-1

Alpaydin, E., 2020. Introduction to Machine Learning, fourth edition. ed. The MIT Press, Cambridge, Massachusetts.

Al-Zaiti, S.S., Martin-Gill, C., Zègre-Hemsey, J.K., Bouzid, Z., Faramand, Z., Alrawashdeh, M.O., Gregg, R.E., Helman, S., Riek, N.T., Kraevsky-Phillips, K., Clermont, G., Akcakaya, M., Sereika, S.M., Van Dam, P., Smith, S.W., Birnbaum, Y., Saba, S., Sejdic, E., Callaway, C.W., 2023. Machine learning for ECG diagnosis and risk stratification of occlusion myocardial infarction. Nat Med. https://doi.org/10.1038/s41591-023-02396-3

Anderson, B., Carr, K., Donahue, C., 2022. Telehealth Now a Permanent Fixture for U.S. Healthcare Delivery | The Chartis Group [WWW Document]. Chartis. URL https://www.chartis.com/insights/telehealth-now-permanent-fixture-us-healthcare-delivery (accessed 4.9.23).

Attia, Z.I., Friedman, P.A., Noseworthy, P.A., Lopez-Jimenez, F., Ladewig, D.J., Satam, G., Pellikka, P.A., Munger, T.M., Asirvatham, S.J., Scott, C.G., Carter, R.E., Kapa, S., 2019. Age and Sex Estimation Using Artificial Intelligence From Standard 12-Lead ECGs. Circ Arrhythm Electrophysiol 12, e007284. https://doi.org/10.1161/CIRCEP.119.007284

Ayers, J.W., Chu, B., Zhu, Z., Leas, E.C., Smith, D.M., Dredze, M., Broniatowski, D.A., 2021. Spread of Misinformation About Face Masks and COVID-19 by Automated Software on

Facebook. JAMA Intern Med 181, 1251–1253. https://doi.org/10.1001/jamainternmed.2021.2498
Ayers, J.W., Poliak, A., Dredze, M., Leas, E.C., Zhu, Z., Kelley, J.B., Faix, D.J., Goodman, A.M., Longhurst, C.A., Hogarth, M., Smith, D.M., 2023. Comparing Physician and Artificial Intelligence Chatbot Responses to Patient Questions Posted to a Public Social Media Forum. JAMA Intern Med 183, 589–596. https://doi.org/10.1001/jamainternmed.2023.1838
Barnett, K.G., Mishuris, R.G., Williams, C.T., Bragg, A., Semenya, A.M., Baldwin, M., Howard, J., Wilson, S.A., Srinivasan, J., 2022. Telehealth's Double-Edged Sword: Bridging or Perpetuating Health Inequities? J Gen Intern Med. https://doi.org/10.1007/s11606-022-07481-w
Bastian, H., Glasziou, P., Chalmers, I., 2010. Seventy-five trials and eleven systematic reviews a day: how will we ever keep up? PLoS Med 7, e1000326. https://doi.org/10.1371/journal.pmed.1000326
Bhayana, R., Bleakney, R.R., Krishna, S., 2023. GPT-4 in Radiology: Improvements in Advanced Reasoning. Radiology 307, e230987. https://doi.org/10.1148/radiol.230987
Bollyky, T.J., Castro, E., Aravkin, A.Y., Bhangdia, K., Dalos, J., Hulland, E.N., Kiernan, S., Lastuka, A., McHugh, T.A., Ostroff, S.M., Zheng, P., Chaudhry, H.T., Ruggiero, E., Turilli, I., Adolph, C., Amlag, J.O., Bang-Jensen, B., Barber, R.M., Carter, A., Chang, C., Cogen, R.M., Collins, J.K., Dai, X., Dangel, W.J., Dapper, C., Deen, A., Eastus, A., Erickson, M., Fedosseeva, T., Flaxman, A.D., Fullman, N., Giles, J.R., Guo, G., Hay, S.I., He, J., Helak, M., Huntley, B.M., Iannucci, V.C., Kinzel, K.E., LeGrand, K.E., Magistro, B., Mokdad, A.H., Nassereldine, H., Ozten, Y., Pasovic, M., Pigott, D.M., Reiner, R.C., Reinke, G., Schumacher, A.E., Serieux, E., Spurlock, E.E., Troeger, C.E., Vo, A.T., Vos, T., Walcott, R., Yazdani, S., Murray, C.J.L., Dieleman, J.L., 2023. Assessing COVID-19 pandemic policies and behaviours and their economic and educational trade-offs across US states from Jan 1, 2020, to July 31, 2022: an observational analysis. Lancet 401, 1341–1360. https://doi.org/10.1016/S0140-6736(23)00461-0
Cabral, S., Restrepo, D., Kanjee, Z., Wilson, P., Crowe, B., Abdulnour, R.-E., Rodman, A., 2024. Clinical Reasoning of a Generative Artificial Intelligence Model Compared With Physicians. JAMA Intern Med. https://doi.org/10.1001/jamainternmed.2024.0295
Chang, A.C., 2020. Intelligence-Based Medicine: Artificial Intelligence and Human Cognition in Clinical Medicine and Healthcare, 1st edition. ed. Academic Press.
Chen, R.J., Wang, J.J., Williamson, D.F.K., Chen, T.Y., Lipkova, J., Lu, M.Y., Sahai, S., Mahmood, F., 2023. Algorithmic fairness in artificial intelligence for medicine and healthcare. Nat Biomed Eng 7, 719–742. https://doi.org/10.1038/s41551-023-01056-8
Cole, C.L., Sengupta, S., Rossetti Née Collins, S., Vawdrey, D.K., Halaas, M., Maddox, T.M., Gordon, G., Dave, T., Payne, P.R.O., Williams, A.E., Estrin, D., 2021. Ten principles for data sharing and commercialization. J Am Med Inform Assoc 28, 646–649. https://doi.org/10.1093/jamia/ocaa260
Cooper, A., Rodman, A., 2023. AI and Medical Education — A 21st-Century Pandora's Box. New England Journal of Medicine. https://doi.org/10.1056/NEJMp2304993
Coyner, A.S., Singh, P., Brown, J.M., Ostmo, S., Chan, R.V.P., Chiang, M.F., Kalpathy-Cramer, J., Campbell, J.P., Imaging and Informatics in Retinopathy of Prematurity Consortium, 2023. Association of Biomarker-Based Artificial Intelligence With Risk of Racial Bias in

Retinal Images. JAMA Ophthalmol 141, 543–552. https://doi.org/10.1001/jamaophthalmol.2023.1310

Crigger, E., Khoury, C., 2019. Making Policy on Augmented Intelligence in Health Care. AMA Journal of Ethics 21, 188–191. https://doi.org/10.1001/amajethics.2019.188.

Daniel, H., Sulmasy, L.S., Health and Public Policy Committee of the American College of Physicians, 2015. Policy recommendations to guide the use of telemedicine in primary care settings: an American College of Physicians position paper. Ann Intern Med 163, 787–789. https://doi.org/10.7326/M15-0498

Detmer, D.E., Shortliffe, E.H., 2014. Clinical Informatics: Prospects for a New Medical Subspecialty. JAMA 311, 2067–2068. https://doi.org/10.1001/jama.2014.3514

Dixon, B. (Ed.), 2022. Health Information Exchange: Navigating and Managing a Network of Health Information Systems, 2nd edition. ed. Academic Press.

Donoho, D., 2017. 50 Years of Data Science. Journal of Computational and Graphical Statistics 26, 745–766. https://doi.org/10.1080/10618600.2017.1384734

Dorr, D.A., Adams, L., Embí, P., 2023. Harnessing the Promise of Artificial Intelligence Responsibly. JAMA 329, 1347–1348. https://doi.org/10.1001/jama.2023.2771

Esteva, A., Robicquet, A., Ramsundar, B., Kuleshov, V., DePristo, M., Chou, K., Cui, C., Corrado, G., Thrun, S., Dean, J., 2019. A guide to deep learning in healthcare. Nature Medicine 25, 24–29. https://doi.org/10.1038/s41591-018-0316-z

Fox, S., Duggan, M., 2013. Health Online 2013. Pew Research Center: Internet, Science & Tech. URL https://www.pewresearch.org/internet/2013/01/15/health-online-2013/ (accessed 9.22.20).

Fridsma, D.B., 2018. Health informatics: a required skill for 21st century clinicians. BMJ 362. https://doi.org/10.1136/bmj.k3043

Friedman, C.P., 2009. A “fundamental theorem” of biomedical informatics. J Am Med Inform Assoc 16, 169–170. https://doi.org/10.1197/jamia.M3092

Galloway, C.D., Valys, A.V., Shreibati, J.B., Treiman, D.L., Petterson, F.L., Gundotra, V.P., Albert, D.E., Attia, Z.I., Carter, R.E., Asirvatham, S.J., Ackerman, M.J., Noseworthy, P.A., Dillon, J.J., Friedman, P.A., 2019. Development and Validation of a Deep-Learning Model to Screen for Hyperkalemia From the Electrocardiogram. JAMA Cardiol 4, 428–436. https://doi.org/10.1001/jamacardio.2019.0640

Gichoya, J.W., Banerjee, I., Bhimireddy, A.R., Burns, J.L., Celi, L.A., Chen, L.-C., Correa, R., Dullerud, N., Ghassemi, M., Huang, S.-C., Kuo, P.-C., Lungren, M.P., Palmer, L.J., Price, B.J., Purkayastha, S., Pyrros, A.T., Oakden-Rayner, L., Okechukwu, C., Seyyed-Kalantari, L., Trivedi, H., Wang, R., Zaiman, Z., Zhang, H., 2022. AI recognition of patient race in medical imaging: a modelling study. Lancet Digit Health 4, e406–e414. https://doi.org/10.1016/S2589-7500(22)00063-2

Glasziou, P., Burls, A., Gilbert, R., 2008. Evidence based medicine and the medical curriculum. BMJ 337. https://doi.org/10.1136/bmj.a1253

Greenes, R., Del Fiol, G. (Eds.), 2023. Clinical Decision Support and Beyond: Progress and Opportunities in Knowledge-Enhanced Health and Healthcare, 3rd edition. ed. Academic Press.

Gunja, M.Z., Gumas, E.D., Williams, R.D., 2023. U.S. Health Care from a Global Perspective, 2022: Accelerating Spending, Worsening Outcomes [WWW Document]. Commonwealth Fund. https://doi.org/10.26099/8ejy-yc74

Han, R., Acosta, J.N., Shakeri, Z., Ioannidis, J.P.A., Topol, E.J., Rajpurkar, P., 2024. Randomised controlled trials evaluating artificial intelligence in clinical practice: a scoping review. Lancet Digit Health 6, e367–e373. https://doi.org/10.1016/S2589-7500(24)00047-5

Hersh, W., 2023. Physician and Medical Student Competence in AI Must Include Broader Competence in Clinical Informatics. Informatics Professor. URL https://informaticsprofessor.blogspot.com/2023/09/physician-and-medical-student.html (accessed 9.15.23).

Hersh, W., Biagioli, F., Scholl, G., Gold, J., Mohan, V., Kassakian, S., Kerns, S., Gorman, P., 2017. From Competencies to Competence: Model, Approach, and Lessons Learned from Implementing a Clinical Informatics Curriculum for Medical Students, in: Health Professionals' Education in the Age of Clinical Information Systems, Mobile Computing and Social Networks. Elsevier, pp. 269–287.

Hersh, W., Ehrenfeld, J., 2020. Clinical Informatics, in: Health Systems Science, 2nd Edition. pp. 156–170.

Hersh, W.R., 2022. Health Informatics: Practical Guide, 8th Edition. Lulu.com.

Hersh, W.R., Gorman, P.N., Biagioli, F.E., Mohan, V., Gold, J.A., Mejicano, G.C., 2014. Beyond information retrieval and electronic health record use: competencies in clinical informatics for medical education. Adv Med Educ Pract 5, 205–212. https://doi.org/10.2147/AMEP.S63903

Holmstrom, L., Christensen, M., Yuan, N., Weston Hughes, J., Theurer, J., Jujjavarapu, M., Fatehi, P., Kwan, A., Sandhu, R.K., Ebinger, J., Cheng, S., Zou, J., Chugh, S.S., Ouyang, D., 2023. Deep learning-based electrocardiographic screening for chronic kidney disease. Commun Med (Lond) 3, 73. https://doi.org/10.1038/s43856-023-00278-w

Hotez, P.J., 2023. The Deadly Rise of Anti-science: A Scientist's Warning. Johns Hopkins University Press, Baltimore.

Hotez, P.J., 2021. Mounting antiscience aggression in the United States. PLoS Biol 19, e3001369. https://doi.org/10.1371/journal.pbio.3001369

Hoyt, R., Muenchen, R. (Eds.), 2019. Introduction to Biomedical Data Science. Lulu.com.

Institute of Medicine, 2012. Best Care at Lower Cost: The Path to Continuously Learning Health Care in America. https://doi.org/10.17226/13444

Institute of Medicine (US) Committee on Quality of Health Care in America, 2000. To Err is Human: Building a Safer Health System. National Academies Press (US), Washington (DC).

James, C.A., Wachter, R.M., Woolliscroft, J.O., 2022. Preparing Clinicians for a Clinical World Influenced by Artificial Intelligence. JAMA 327, 1333–1334. https://doi.org/10.1001/jama.2022.3580

Jumper, J., Evans, R., Pritzel, A., Green, T., Figurnov, M., Ronneberger, O., Tunyasuvunakool, K., Bates, R., Žídek, A., Potapenko, A., Bridgland, A., Meyer, C., Kohl, S.A.A., Ballard, A.J., Cowie, A., Romera-Paredes, B., Nikolov, S., Jain, R., Adler, J., Back, T., Petersen, S., Reiman, D., Clancy, E., Zielinski, M., Steinegger, M., Pacholska, M., Berghammer, T., Bodenstein, S., Silver, D., Vinyals, O., Senior, A.W., Kavukcuoglu, K., Kohli, P., Hassabis, D., 2021. Highly accurate protein structure prediction with AlphaFold. Nature 596, 583–589. https://doi.org/10.1038/s41586-021-03819-2

Kakani, P., Chandra, A., Mullainathan, S., Obermeyer, Z., 2020. Allocation of COVID-19 Relief Funding to Disproportionately Black Counties. JAMA. https://doi.org/10.1001/jama.2020.14978

Kanjee, Z., Crowe, B., Rodman, A., 2023. Accuracy of a Generative Artificial Intelligence Model in a Complex Diagnostic Challenge. JAMA 330, 78–80. https://doi.org/10.1001/jama.2023.8288
Katz, U., Cohen, E., Shachar, E., Somer, J., Fink, A., Morse, E., Shreiber, B., Wolf, I., 2024. GPT versus Resident Physicians — A Benchmark Based on Official Board Scores. NEJM AI 0, AIdbp2300192. https://doi.org/10.1056/AIdbp2300192
Kim, E., Van Cain, M., Hron, J., 2023. Survey of clinical informatics fellows graduating 2016-2024: experiences before and during fellowship. J Am Med Inform Assoc 30, 1608–1613. https://doi.org/10.1093/jamia/ocad112
Kumah-Crystal, Y., Mankowitz, S., Embi, P., Lehmann, C.U., 2023. ChatGPT and the clinical informatics board examination: the end of unproctored maintenance of certification? J Am Med Inform Assoc ocad104. https://doi.org/10.1093/jamia/ocad104
Kung, T.H., Cheatham, M., Medenilla, A., Sillos, C., De Leon, L., Elepaño, C., Madriaga, M., Aggabao, R., Diaz-Candido, G., Maningo, J., Tseng, V., 2023. Performance of ChatGPT on USMLE: Potential for AI-assisted medical education using large language models. PLOS Digit Health 2, e0000198. https://doi.org/10.1371/journal.pdig.0000198
Langlotz, C.P., 2019. Will Artificial Intelligence Replace Radiologists? Radiol Artif Intell 1, e190058. https://doi.org/10.1148/ryai.2019190058
Leape, L.L., 2021. Making Healthcare Safe: The Story of the Patient Safety Movement. Springer International Publishing. https://doi.org/10.1007/978-3-030-71123-8
Lee, P., Bubeck, S., Petro, J., 2023a. Benefits, Limits, and Risks of GPT-4 as an AI Chatbot for Medicine. N Engl J Med 388, 1233–1239. https://doi.org/10.1056/NEJMsr2214184
Lee, P., Goldberg, C., Kohane, I., 2023b. The AI Revolution in Medicine: GPT-4 and Beyond, 1st edition. ed. Pearson.
Leonhardt, D., 2021. Red Covid. The New York Times.
Liaw, W., Kueper, J.K., Lin, S., Bazemore, A., Kakadiaris, I., 2022. Competencies for the Use of Artificial Intelligence in Primary Care. Ann Fam Med 20, 559–563. https://doi.org/10.1370/afm.2887
McGlynn, E.A., 2020. Improving the Quality of U.S. Health Care — What Will It Take? New England Journal of Medicine 383, 801–803. https://doi.org/10.1056/NEJMp2022644
McGlynn, E.A., Asch, S.M., Adams, J., Keesey, J., Hicks, J., DeCristofaro, A., Kerr, E.A., 2003. The Quality of Health Care Delivered to Adults in the United States. New England Journal of Medicine 348, 2635–2645. https://doi.org/10.1056/NEJMsa022615
McGraw, D., Petersen, C., 2020. From Commercialization to Accountability: Responsible Health Data Collection, Use, and Disclosure for the 21st Century. Appl Clin Inform 11, 366–373. https://doi.org/10.1055/s-0040-1710392
Mitsuyama, Y., Matsumoto, T., Tatekawa, H., Walston, S.L., Kimura, T., Yamamoto, A., Watanabe, T., Miki, Y., Ueda, D., 2023. Chest radiography as a biomarker of ageing: artificial intelligence-based, multi-institutional model development and validation in Japan. The Lancet Healthy Longevity 0. https://doi.org/10.1016/S2666-7568(23)00133-2
Nori, H., Lee, Y.T., Zhang, S., Carignan, D., Edgar, R., Fusi, N., King, N., Larson, J., Li, Y., Liu, W., Luo, R., McKinney, S.M., Ness, R.O., Poon, H., Qin, T., Usuyama, N., White, C., Horvitz, E., 2023. Can Generalist Foundation Models Outcompete Special-Purpose Tuning? Case Study in Medicine. https://doi.org/10.48550/arXiv.2311.16452

Obermeyer, Z., Powers, B., Vogeli, C., Mullainathan, S., 2019. Dissecting racial bias in an algorithm used to manage the health of populations. Science 366, 447–453. https://doi.org/10.1126/science.aax2342

Omiye, J.A., Gui, H., Rezaei, S.J., Zou, J., Daneshjou, R., 2024. Large Language Models in Medicine: The Potentials and Pitfalls : A Narrative Review. Ann Intern Med 177, 210–220. https://doi.org/10.7326/M23-2772

Plana, D., Shung, D.L., Grimshaw, A.A., Saraf, A., Sung, J.J.Y., Kann, B.H., 2022. Randomized Clinical Trials of Machine Learning Interventions in Health Care: A Systematic Review. JAMA Netw Open 5, e2233946. https://doi.org/10.1001/jamanetworkopen.2022.33946

Poplin, R., Varadarajan, A.V., Blumer, K., Liu, Y., McConnell, M.V., Corrado, G.S., Peng, L., Webster, D.R., 2018. Prediction of cardiovascular risk factors from retinal fundus photographs via deep learning. Nat Biomed Eng 2, 158–164. https://doi.org/10.1038/s41551-018-0195-0

Pylypchuk, Y., Everson, J., 2023. Interoperability and Methods of Exchange among Hospitals in 2021 [WWW Document]. ONC Data Brief | No.64. URL https://www.healthit.gov/data/data-briefs/interoperability-and-methods-exchange-among-hospitals-2021

Pyrros, A., Borstelmann, S.M., Mantravadi, R., Zaiman, Z., Thomas, K., Price, B., Greenstein, E., Siddiqui, N., Willis, M., Shulhan, I., Hines-Shah, J., Horowitz, J.M., Nikolaidis, P., Lungren, M.P., Rodríguez-Fernández, J.M., Gichoya, J.W., Koyejo, S., Flanders, A.E., Khandwala, N., Gupta, A., Garrett, J.W., Cohen, J.P., Layden, B.T., Pickhardt, P.J., Galanter, W., 2023. Opportunistic detection of type 2 diabetes using deep learning from frontal chest radiographs. Nat Commun 14, 4039. https://doi.org/10.1038/s41467-023-39631-x

Rajkomar, A., Kannan, A., Chen, K., Vardoulakis, L., Chou, K., Cui, C., Dean, J., 2019. Automatically Charting Symptoms From Patient-Physician Conversations Using Machine Learning. JAMA Intern Med 179, 836–838. https://doi.org/10.1001/jamainternmed.2018.8558

Rajkomar, A., Oren, E., Chen, K., Dai, A.M., Hajaj, N., Hardt, M., Liu, P.J., Liu, X., Marcus, J., Sun, M., Sundberg, P., Yee, H., Zhang, K., Zhang, Y., Flores, G., Duggan, G.E., Irvine, J., Le, Q., Litsch, K., Mossin, A., Tansuwan, J., Wang, D., Wexler, J., Wilson, J., Ludwig, D., Volchenboum, S.L., Chou, K., Pearson, M., Madabushi, S., Shah, N.H., Butte, A.J., Howell, M.D., Cui, C., Corrado, G.S., Dean, J., 2018. Scalable and accurate deep learning with electronic health records. npj Digital Medicine 1, 1–10. https://doi.org/10.1038/s41746-018-0029-1

Rajpurkar, P., Chen, E., Banerjee, O., Topol, E.J., 2022. AI in health and medicine. Nat Med 1–8. https://doi.org/10.1038/s41591-021-01614-0

Rajpurkar, P., Lungren, M.P., 2023. The Current and Future State of AI Interpretation of Medical Images. N Engl J Med 388, 1981–1990. https://doi.org/10.1056/NEJMra2301725

Reader, R., 2022. The telehealth bubble has burst. Time to figure out what's next [WWW Document]. Fast Company. URL https://www.fastcompany.com/90706243/telehealth-in-2021-and-beyond (accessed 1.6.22).

Russell, R.G., Lovett Novak, L., Patel, M., Garvey, K.V., Craig, K.J.T., Jackson, G.P., Moore, D., Miller, B.M., 2023. Competencies for the Use of Artificial Intelligence-Based Tools by Health Care Professionals. Acad Med 98, 348–356. https://doi.org/10.1097/ACM.0000000000004963

Safran, C., 2009. Informatics training for clinicians is more important than hardware and software. Yearb Med Inform 164–165.

Sahni, N.R., Carrus, B., 2023. Artificial Intelligence in U.S. Health Care Delivery. N Engl J Med 389, 348–358. https://doi.org/10.1056/NEJMra2204673

Sangha, V., Nargesi, A.A., Dhingra, L.S., Khunte, A., Mortazavi, B.J., Ribeiro, A.H., Banina, E., Adeola, O., Garg, N., Brandt, C.A., Miller, E.J., Ribeiro, A.L.J., Velazquez, E.J., Giatti, L., Barreto, S.M., Foppa, M., Yuan, N., Ouyang, D., Krumholz, H.M., Khera, R., 2023. Detection of Left Ventricular Systolic Dysfunction From Electrocardiographic Images. Circulation. https://doi.org/10.1161/CIRCULATIONAHA.122.062646

Serrano, L., 2023. What Are Transformer Models and How Do They Work? [WWW Document]. Context by Cohere. URL https://txt.cohere.com/what-are-transformer-models/ (accessed 5.3.23).

Shortliffe, E.H., 2019. Artificial Intelligence in Medicine: Weighing the Accomplishments, Hype, and Promise. Yearb Med Inform 28, 257–262. https://doi.org/10.1055/s-0039-1677891

Shortliffe, E.H., 2010. Biomedical informatics in the education of physicians. JAMA 304, 1227–1228. https://doi.org/10.1001/jama.2010.1262

Skochelak, S. (Ed.), 2020. Health Systems Science, 2nd Edition.

Sule, S., DaCosta, M.C., DeCou, E., Gilson, C., Wallace, K., Goff, S.L., 2023. Communication of COVID-19 Misinformation on Social Media by Physicians in the US. JAMA Netw Open 6, e2328928. https://doi.org/10.1001/jamanetworkopen.2023.28928

Tang, A.S., Rankin, K.P., Cerono, G., Miramontes, S., Mills, H., Roger, J., Zeng, B., Nelson, C., Soman, K., Woldemariam, S., Li, Y., Lee, A., Bove, R., Glymour, M., Aghaeepour, N., Oskotsky, T.T., Miller, Z., Allen, I.E., Sanders, S.J., Baranzini, S., Sirota, M., 2024. Leveraging electronic health records and knowledge networks for Alzheimer's disease prediction and sex-specific biological insights. Nat Aging 4, 379–395. https://doi.org/10.1038/s43587-024-00573-8

The Disinformation Dozen [WWW Document], 2021. . Center for Countering Digital Hate. URL https://www.counterhate.com/disinformationdozen (accessed 9.28.21).

Topol, E., 2019. Deep Medicine: How Artificial Intelligence Can Make Healthcare Human Again, Illustrated Edition. ed. Basic Books, New York.

Topol, E.J., 2023. As artificial intelligence goes multimodal, medical applications multiply. Science 381, adk6139. https://doi.org/10.1126/science.adk6139

Tu, T., Palepu, A., Schaekermann, M., Saab, K., Freyberg, J., Tanno, R., Wang, A., Li, B., Amin, M., Tomasev, N., Azizi, S., Singhal, K., Cheng, Y., Hou, L., Webson, A., Kulkarni, K., Mahdavi, S.S., Semturs, C., Gottweis, J., Barral, J., Chou, K., Corrado, G.S., Matias, Y., Karthikesalingam, A., Natarajan, V., 2024. Towards Conversational Diagnostic AI. https://doi.org/10.48550/arXiv.2401.05654

Ueda, D., Matsumoto, T., Ehara, S., Yamamoto, A., Walston, S.L., Ito, A., Shimono, T., Shiba, M., Takeshita, T., Fukuda, D., Miki, Y., 2023. Artificial intelligence-based model to classify cardiac functions from chest radiographs: a multi-institutional, retrospective model development and validation study. Lancet Digit Health S2589-7500(23)00107–3. https://doi.org/10.1016/S2589-7500(23)00107-3

Verma, S., 2020. Early Impact Of CMS Expansion Of Medicare Telehealth During COVID-19. Health Affairs. URL https://www.healthaffairs.org/do/10.1377/hblog20200715.454789/full/ (accessed 8.18.20).

Weiss, J., Raghu, V.K., Paruchuri, K., Zinzuwadia, A., Natarajan, P., Aerts, H.J.W.L., Lu, M.T., 2024. Deep Learning to Estimate Cardiovascular Risk From Chest Radiographs : A Risk Prediction Study. Ann Intern Med. https://doi.org/10.7326/M23-1898

Wood, D., Brumfiel, G., 2022. Pro-Trump counties continue to suffer far higher COVID death tolls. NPR.

Information is Different Now That You're a Doctor

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About me

- Professor in Department of Medical Informatics & Clinical Epidemiology (DMICE)
- Medical school and residency in internal medicine at University of Illinois Chicago, followed by fellowship in medical informatics at Harvard University
- At OHSU since 1990
- Served as Inaugural Chair of DMICE from 2003-2022
- Have developed informatics educational programs for informaticians, physicians, and others over the years

- Disclosures/Conflict of Interest – None

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Session Objectives

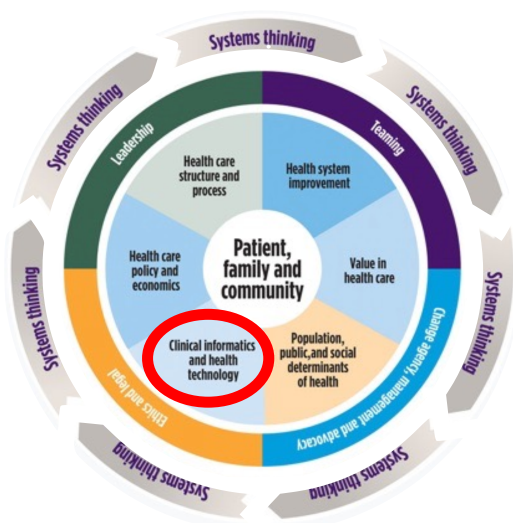
- Define the field of clinical informatics and the central role that data and information play in medicine and healthcare
- Describe how information is different from a medical professional perspective, including how it is used for care and other purposes, kept private and secure, and shared with patients
- Discuss the impact and challenges of artificial intelligence (AI) in medicine
- Describe the discipline of clinical informatics as it pertains to healthcare professionals, including those who work professionally in it

Clinical informatics is part of (but not limited to) Health Systems Science

Hersh and Ehrenfeld, *Clinical Informatics*, Chapter 10 in *Health Systems Science* (Skochelak et al., 2nd edition, 2020)

For more information:

- Hersh (Ed.), *Health Informatics: Practical Guide, 8th Edition*, Lulu.com, 2022
  - http://www.informaticsbook.info/
- What is Biomedical Informatics?
  - http://informatics.health



Information and the new medical student (Shortliffe, 2010)

WHEN I FIRST MEET WITH PRECLINICAL MEDICAL students, I make a point of asking them what they believe will receive the greatest focus of their attention once they are in clinical practice. The most common response, not surprisingly, is patients, and yet it is clear to experienced practitioners that the correct answer is information—in the service of their patients. The need for information underlies essentially all clinical work: the questions asked during a patient history, the tests ordered, the books read, and the questions asked of colleagues. A key correlate to information is knowledge, that elusive concept that justifies all the years of education and training, and that provides the background sense of what is true that allows gathering and interpreting information appropriately. Clinicians often start with data (eg, "Mr Jones' creatinine is 5.2 mg/dL"), those individual elements that combine to allow a synthesis of observations with what is known in order to create summary statements of information (eg, "Mr Jones has renal failure").

Information skills are essential for medical practice (Glasziou, 2008)

The search engine is now as essential as the stethoscope

What we know about diseases, diagnosis, and effective treatments is growing rapidly. Today health professionals cannot solely rely on what they were first taught if they want to do the best for their patients. It has repeatedly been shown that clinical performance deteriorates over time.[1] A commitment to lifelong learning must be integral to ethical professional practice. However, the speed of the increase in knowledge—more than 2000 new research papers are added to Medline each day—represents a challenge.[2] The skills needed to find potentially relevant studies quickly and reliably, to separate the wheat from the chaff, and to apply sound research findings to patient care have today become as essential as skills with a stethoscope.

Most of you are "digital natives" but

- Not the same as competence in clinical informatics
- Your relationship with information changes as you become a medical professional
- You become responsible not only for "knowing" information, but also
  - Using it to provide better care of patients
  - Leveraging it to improve the healthcare system
  - Protecting privacy and confidentiality of patients
  - Acting professionally with information
  - Critically analyzing AI, data used for it, and potential biases
- Computer literacy is a prerequisite, not an end

Why is information different now that you're in medicine?

- Growth of medical knowledge
  - 75 new clinical trials and 11 systematic reviews published each day (Bastian, 2010)
    - To say nothing of the basic science, especially genomics
- Medical knowledge no longer the exclusive purview of physicians
  - >80% of all Internet users search for personal health information (Fox, 2013)

Many problems in healthcare have information-related solutions

- Quality – not as good as it could be; slightly more than half of patients get care they should get (McGlynn, 2003; McGlynn, 2020)
- Safety – errors cause morbidity and mortality; many preventable (IOM, 2000; Leape, 2021)
- Cost – US spends more and gets less (Gunja, 2023)
- Inaccessible information – missing information still not always accessible (Pylypchuk, 2023)

EHR is more than "charting"

- Physicians must be able to
  - Move from one vendor system to another
  - Effectively use *clinical decision support* to remind us of things to do and warn us about things not to do (Greenes, 2023)
  - Access information from other settings where patient received care through *health information exchange* (Dixon, 2022)
  - Apply *data analytics*, especially in setting of population health management, to achieve quality, safety, and cost-effectiveness
  - Integrate *artificial intelligence* (AI) in care of patients

Patients want more access to data and information too

- They have access to just about all of the same knowledge resources we can access through the *personal health record* (PHR)
  - And increasingly all of their medical record
- They want to interact with us digitally and want to interact with healthcare the way they interact with airlines, retailers, banks, etc.
- They want access to and control over their data
  - We must educate them in the risks and benefits

Those who pay for care want more accountability from us

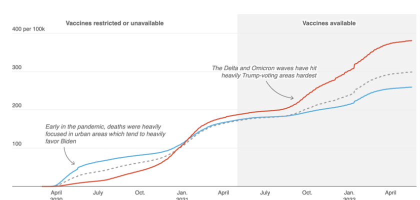
- Purchasers (employers, government) and payors (insurers) want assurance that care provided is high-quality and cost-effective
  - *Clinical decision support* aims to help physicians make best choices and avoid errors
  - Use of *quality measurement and improvement*
- Leading to calls for a *learning health system*, where we learn from data to improve care (IOM, 2012)

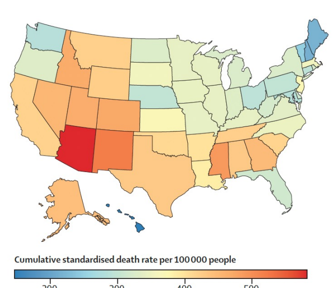
We also have responsibilities around data and information

- Patients expect us to keep their information private and secure
  - *Health Insurance Portability and Accountability Act* (HIPAA) regulations guide our actions with protected health information (PHI)
    - Treatment, payment, and operations (TPO) allow disclosure
    - Other uses require patient consent
    - Only applies to data within healthcare system
- Our public-facing persona must be professional, especially on social media
- Growing recognition of bias in data and algorithms
  - Algorithms mis-appropriating resources (Obermeyer, 2019; Kakani, 2020)
  - Companies and others “monetizing” our personal health data (McGraw, 2020)
  - Implementing responsible (Dorr, 2023) and fair (Chen, 2023) AI

Including some lessons learned from COVID-19

- Disinformation spread widely by small number of people (Disinformation Dozen, 2021), including about 50 physicians (Sule, 2023), augmented via large following and automated means on social media, e.g., Facebook (Ayers, 2021)
- Impact related to vaccine uptake and (indirectly) political leanings (Wood, 2022; Bollyky, 2023)
- Leading to assaults on science and scientists (Hotez, 2021; Hotez, 2023)





We must also manage and lead the introduction of AI in medicine

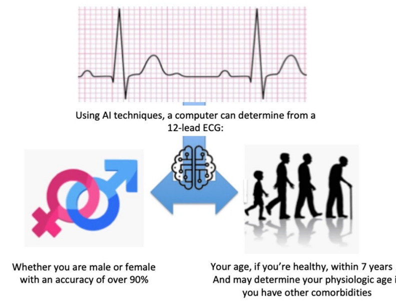
- AI – “information systems and algorithms capable of performing tasks associated with human intelligence” (Rajpurkar, 2022; Sahni, 2023)
  - Modern success from advances machine learning (ML) – “computer programs that learn without being explicitly programmed” (Alpaydin, 2020)
- AI is not new (Shortliffe, 2019)
  - First usage began in 1960s, aiming to build computer programs based on human-constructed knowledge bases
  - Some successes but difficult to scale, leading to “AI winter” of 1990s
- Re-emergence of AI in 2000s with advances in ML, much larger data availability, and more powerful and Internet-based computers
  - Major advances in ML from *deep learning* (Esteva, 2019; Topol, 2019)
  - Initial successes in *predictive AI* but now *generative AI*, e.g., ChatGPT (Lee, 2023)
  - Has led to new field of *data science* (Donoho, 2017; in biomedicine: Hoyt, 2019)

Impressive results of predictive AI on various types of data

- Most success has been with image interpretation (Rajpurkar, 2023); examples include
  - Radiology – chest x-rays for diagnosis of pneumonia and tuberculosis
  - Ophthalmology – retinal images for diagnosis of diabetic retinopathy
  - Dermatology – skin lesions for diagnosis of cancer
  - Pathology – breast cancer slides to predict metastasis
- Achievements in other areas
  - Predicting adverse events in hospitalizations (Rajkomar, 2018)
  - Generating clinical notes from patient and physician verbal interaction (Rajkomar, 2019)
  - Predicting protein folding from amino acid sequences (Abramson, 2024)
  - Predict Alzheimer’s Disease up to 7 years before diagnosis (Tang, 2024)

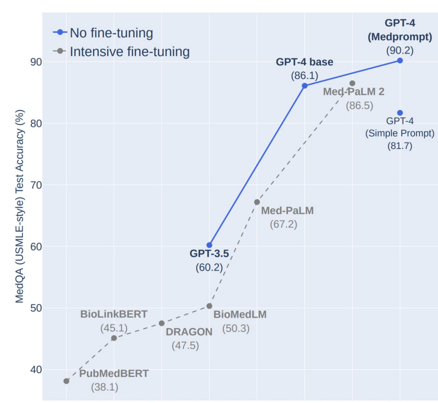
Including ability to “see” where humans cannot (Topol, 2023)

- Retinal images
  - Age, sex, and cardiovascular risk determination from retinal images (Poplin, 2018)
  - Race (Coyner, 2023)
- ECG
  - Age and sex determination (Attia, 2019)
  - Chronic kidney disease (Holmstrom, 2023)
  - Left ventricular systolic dysfunction from ECG images (Sangha, 2023)
- Chest x-ray
  - Race (Gichoya, 2022)
  - Cardiac function and valvular heart diseases (Ueda, 2023)
  - Diabetes mellitus (Pyrros, 2023)
  - Correlation with chronological age in healthy cohorts and, for various chronic diseases, difference between estimated age and chronological age (Mitsuyama, 2023)
  - Cardiac risk as accurately as common models, e.g., atherosclerotic cardiovascular disease (ASCVD) (Weiss, 2024)



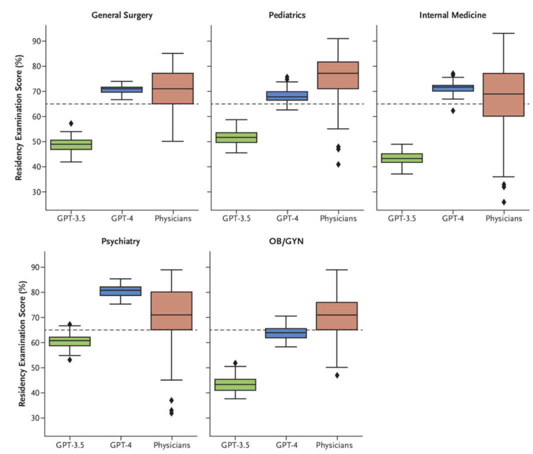
And now, generative AI and large language models (LLM)

- Introduction of ChatGPT in November, 2022 brought a new type of AI into focus: generative AI
- LLMs based on transformer models trained with large amounts of text (Omiye, 2024)
- Although imperfect and sometimes prone to confabulation (Lee, 2023), impressive performance in medicine and beyond, e.g.,
  - US Medical Licensing Exam (USMLE) (Nori, 2023)
  - Board exams in e.g., radiology (Bhayana, 2023) and clinical informatics (Kumah-Crystal, 2023)
  - *New England Journal of Medicine* clinical cases (Kanjee, 2023)
  - Answering questions in social media forums (Ayers, 2023)
  - Drafting letters to patients (Ali, 2023)



Performing comparable to physicians

- Physician history-taking, diagnostic accuracy, management reasoning, communication skills, and empathy (Tu, 2024)
- Attending physicians and residents in diagnostic accuracy, correct clinical reasoning, and cannot-miss diagnosis inclusion (Cabral, 2024)
- Post-residency board exams (Katz, 2024)



Will AI replace physicians?

- Real-world use and evidence base still modest
  - Systematic reviews of clinical trials of predictive AI systems show small number of trials (relative to predictive modeling papers), mediocre methodologies, and mixed results (Plana, 2022; Han, 2024)
- “AI won’t replace radiologists, but radiologists who use AI will replace radiologists who don’t,” (Langlotz, 2019)

We must also learn to practice medicine by alternative modalities

- Telehealth/telemedicine – clinical care separated by time and/or distance (Daniel, 2015)
  - Synchronous – real-time
  - Asynchronous – sending images, video, etc.
- Usage exploded at onset of pandemic, aided by relaxation of rules (Verma, 2020)
  - Has reduced from peak but well above pre-pandemic baseline (Anderson, 2022)

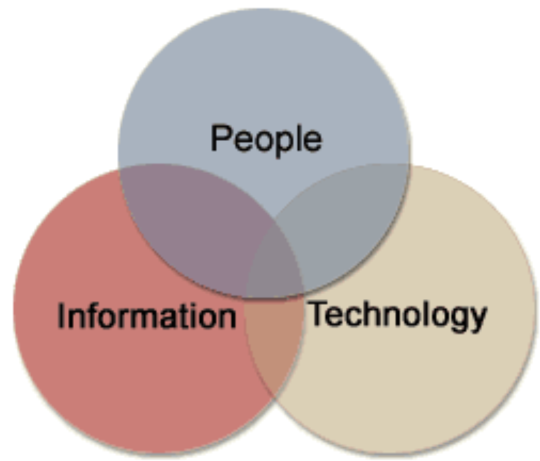
Informatics and medical education

- "Informatics training for clinicians is more important than hardware and software" (Safran, 2009)
- Health informatics is a "required skill for 21st century clinicians" (Fridsma, 2018)
- Competencies (Hersh, 2014; Hersh, 2023) and curricula (Hersh, 2017)
- Clinicians must be prepared to practice in a world of AI (James, 2022)
- New AI-competency frameworks highlight what health professions students must master (Russell, 2023; Liaw, 2023)

1. Find, search, and apply knowledge-based information to patient care and other clinical tasks
2. Effectively read from, and write to, the electronic health record (EHR) for patient care and other clinical activities
3. Use and guide implementation of clinical decision support (CDS)
4. Provide care using population health management approaches
5. Protect patient privacy and security
6. Use information technology to improve patient safety
7. Engage in quality measurement selection and improvement
8. Use health information exchange (HIE) to identify and access patient information across clinical settings
9. Engage patients to improve their health and care delivery though personal health records and patient portals
10. Maintain professionalism in use of information technology tools, including social media
11. Provide clinical care via telemedicine and refer patients as indicated
12. Apply personalized/precision medicine
13. Participate in practice-based clinical and translational research
14. Use and critique artificial intelligence (AI) applications in clinical care

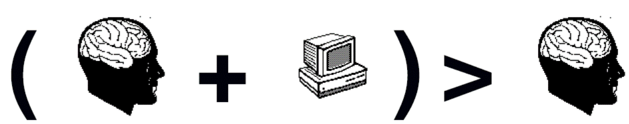
Clinical informatics

- Part of larger *biomedical and health informatics*, the field concerned with the optimal use of information, often aided by technology, to improve
  - Individual health
  - Healthcare
  - Public health
  - Biomedical research
- (Detmer, 2014; Hersh, 2020; Hersh 2022)

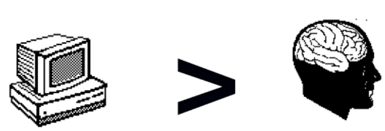


Fundamental theorem of informatics

Goal of informatics is



Goal is not



(Friedman, 2009)

Clinical informatics

- Competence required of all; career opportunities available for some
- Growing number of physicians work in roles such as *Chief Medical Informatics Officer* (CMIO) or others in academia or industry
- Clinical informatics now a subspecialty of all medical specialties (Detmer, 2014)
  - ACGME-accredited fellowships gold standard for training (Kim, 2023)

What can you do in clinical informatics?

- Informatics skills are essential to the practice of the 21st century physician
  - You should master informatics just as you master any other clinical skill
- For those interested as a career, plenty of opportunities in medical school and beyond
  - Scholarly projects, electives, and more
  - Advanced study – e.g., graduate degree and/or fellowship
  - Clinical informatics subspecialty fellowship

Questions to ponder

- What are the most important ways that clinical informatics can benefit clinical practice?
- How can and should we engage patients in the use of informatics tools?
- How can we make the best use of AI while minimizing its risks?