비전문가가 외부의 피드백에 의존하는 반면, 전문가들은 효과적이고 효율적인 문제 해결자이다.

* Nonexperts are dependent primarily on feedback from external sources for error detection and correction.[21](https://www.sciencedirect.com/science/article/pii/S1931720409001974" \l "bib21), [22](https://www.sciencedirect.com/science/article/pii/S1931720409001974" \l "bib22)
  + Braido, F., Santus, P., Corsico, A. G., Di Marco, F., Melioli, G., Scichilone, N., & Solidoro, P. (2018). Chronic obstructive lung disease “expert system”: Validation of a predictive tool for assisting diagnosis. *International journal of chronic obstructive pulmonary disease*, 1747-1753.
  + Glaser, R. (2014). Changing the agency for learning: Acquiring expert performance. In *The road to excellence* (pp. 303-311). Psychology Press.
* Experts are effective and efficient problem solvers, using forward reasoning to reach a diagnosis and treatment strategy rapidly and make fewer cognitive errors.[23](https://www.sciencedirect.com/science/article/pii/S1931720409001974" \l "bib23), [24](https://www.sciencedirect.com/science/article/pii/S1931720409001974" \l "bib24), [25](https://www.sciencedirect.com/science/article/pii/S1931720409001974" \l "bib25), [26](https://www.sciencedirect.com/science/article/pii/S1931720409001974" \l "bib26), [27](https://www.sciencedirect.com/science/article/pii/S1931720409001974" \l "bib27), [28](https://www.sciencedirect.com/science/article/pii/S1931720409001974" \l "bib28)
  + Halm, E. A., Lee, C., & Chassin, M. R. (2002). Is volume related to outcome in health care? A systematic review and methodologic critique of the literature. *Annals of internal medicine*, *137*(6), 511-520.
  + Proctor, R. W., & Dutta, A. (1995). *Skill acquisition and human performance*. Sage Publications, Inc.
  + VanLehn, K. (1996). Cognitive skill acquisition. *Annual review of psychology*, *47*(1), 513-539.
  + Ericsson, K. A., & Lehmann, A. C. (1996). Expert and exceptional performance: Evidence of maximal adaptation to task constraints. *Annual review of psychology*, *47*(1), 273-305.
  + Choudhry, N. K., Fletcher, R. H., & Soumerai, S. B. (2005). Systematic review: the relationship between clinical experience and quality of health care. *Annals of Internal medicine*, *142*(4), 260-273.
  + Moskowitz, A. J., Kuipers, B. J., & Kassirer, J. P. (1988). Dealing with uncertainty, risks, and tradeoffs in clinical decisions: a cognitive science approach. *Annals of Internal Medicine*, *108*(3), 435-449.

전문의라고 하더라도 잘못된 결론을 내릴 수 있다.

* Some pathologies, such as urinary diseases ([Abu-Naser & Shaath, 2016](https://www.sciencedirect.com/science/article/pii/S0957417421003419#b0015)) or lower back pain problems ([Abu-Naser & AlDahdooh, 2016](https://www.sciencedirect.com/science/article/pii/S0957417421003419" \l "b0010)), are still mis-diagnosed, translating into erroneous therapies that do not help the patient.
  + Abu-Naser, S. S., & Shaath, M. Z. (2016). Expert system urination problems diagnosis.
  + Abu-Naser, S. S., & ALDAHDOOH, R. (2016). Lower back pain expert system diagnosis and treatment.
* Other conditions, such as motor symptoms of patients with neurological disorders ([Bobić et al., 2019](https://www.sciencedirect.com/science/article/pii/S0957417421003419" \l "b0065)) or chronic obstructive disease ([Braido et al., 2018](https://www.sciencedirect.com/science/article/pii/S0957417421003419" \l "b0075)), can be particularly difficult to be differentiated and recognized properly even by the experts.
  + Bobić, V., Djurić-Jovičić, M., Dragašević, N., Popović, M. B., Kostić, V. S., & Kvaščev, G. (2019). An expert system for quantification of bradykinesia based on wearable inertial sensors. *Sensors*, *19*(11), 2644.
  + Braido, F., Santus, P., Corsico, A. G., Di Marco, F., Melioli, G., Scichilone, N., & Solidoro, P. (2018). Chronic obstructive lung disease “expert system”: Validation of a predictive tool for assisting diagnosis. *International journal of chronic obstructive pulmonary disease*, 1747-1753.

의료 진단은 다양한 요인들을 고려해야하는 복잡한 문제이다.

* The problem of medical diagnosis is an issue complicated by different factors ([Kadhim et al., 2011](https://www.sciencedirect.com/science/article/pii/S0957417421003419" \l "b0205)),
  + Kadhim, M. A., Alam, M. A., & Kaur, H. (2011). Design and implementation of fuzzy expert system for back pain diagnosis. *International Journal of Innovative Technology & Creative Engineering*, *1*(9), 16-22.

다양한 정보에 대한 인식과 해석에 대해 고려해야 한다. .

* this matter contemplates the acquisition and interpretation of multiple kinds of information: patient’s symptoms can be obtained from his/her anamnesis, signs, laboratory test results, ultrasonic results, X-ray findings and so on ([Dev et al., 2016](https://www.sciencedirect.com/science/article/pii/S0957417421003419" \l "b0115)).
  + Dev, U., Sultana, A., & Mitra, N. K. (2016). Medical knowledge and fuzzy expert system.

(의료 진단과 관련된) 정보를 옳게 해석하는 것은 오직 전문가의 지식(Expertise)와 인식에만 의존한다.

* Interpreting this information in a correct way is a delicate matter, the interpretation depending solely on the expertise and perception of the practitioner ([Sikchi et al., 2013](https://www.sciencedirect.com/science/article/pii/S0957417421003419" \l "b0445))
  + Sikchi, S. S., Sikchi, S., & Ali, M. S. (2013). Fuzzy expert systems (FES) for medical diagnosis. *International Journal of Computer Applications*, *63*(11).

의료 진단은 1) 지식의 부족, 2) 원인과 결과가 1 – 1 관계가 아니며, 3) 오류로부터 영향을 받고, 4) 정보가 연속적이지 않을 수 있어 어렵다.

* The problems of diagnosis do not only arise from the incompleteness of this knowledge, but also and most immediately from the theoretical and practical limitations associated with the reversal of the chain of implications that lead from an initial cause to its observable effects
* First of all, medical cause-effect relationships, the relations between diagnoses and their symptoms, are hardly ever one-to-one. Differentiation of diagnoses that share an overlapping range of symptoms is therefore inherently difficult. Secondly, all observation is subject to error: the correction of this error, stochastic in nature, requires strong assumptions that do not hold in practice. Lastly, the required observations can often not be made on a continuous basis.
  + Steimann, F., & Adlassnig, K. P. (1998). Fuzzy medical diagnosis. *Handbook of fuzzy computation*, *13*, 1-16.

**Expert systems: Definitions, advantages and issues in medical field applications**

Expert system이란 다양한 영역의 전문가의 의견을 공유하고 베포하는 수단이다.

* Expert systems (ESs) are a mean through which share and distribute knowledge ([Hendriks, 1999](https://www.sciencedirect.com/science/article/pii/S0957417421003419" \l "b0165), [Oleshchuk and Fensli, 2011](https://www.sciencedirect.com/science/article/pii/S0957417421003419" \l "b0300)), being it acquired directly or indirectly from domain experts of different scientific areas.
  + Hendriks, P. (1999). Why share knowledge? The influence of ICT on the motivation for knowledge sharing. *Knowledge and process management*, *6*(2), 91-100.
  + Oleshchuk, V., & Fensli, R. (2011). Remote patient monitoring within a future 5G infrastructure. *Wireless Personal Communications*, *57*, 431-439.

Expert system은 전문가에 대한 대체까진 아니더라도 노하우 제공, 지원해줄 수 있다.

* They are not only an aid to users lacking a specific know-how, but also supports ([Oyedeji, Osifeko, Folorunsho, Abolade, & Ade-Ikuesan, 2019](https://www.sciencedirect.com/science/article/pii/S0957417421003419" \l "b0305)), if not even substitutes ([Ahmed et al., 2019](https://www.sciencedirect.com/science/article/pii/S0957417421003419" \l "b0030)), for human experts.
  + Oyedeji, A. O., Osifeko, M. O., Folorunsho, O., Abolade, O. R., & Ade-Ikuesan, O. O. (2019). Design and implementation of a medical diagnostic expert system. *J. Eng.*, *10*, 103-9.

Expert system은 사람의 의사결정 과정을 모방하는데 근간을 둬야 한다.

* Therefore, the power of an ES should lay in its ability to mimic the human decision process ([Kim et al., 2017](https://www.sciencedirect.com/science/article/pii/S0957417421003419" \l "b0215), [Mirmozaffari, 2019](https://www.sciencedirect.com/science/article/pii/S0957417421003419" \l "b0275)), especially when applied in the medical field.
  + Kim, E. H., Oh, S. K., & Pedrycz, W. (2017). Reinforced rule-based fuzzy models: Design and analysis. *Knowledge-Based Systems*, *119*, 44-58.
  + Mirmozaffari, M. (2019). Presenting a medical expert system for diagnosis and treatment of nephrolithiasis. *European Journal of Medical and Health Sciences*, *1*(1).

의사/전문가 및 ES 와의 시너지는 이미 신뢰성과 효율성 측면에서 진단 및 치료 프로세스에 개선을 가져오는 것으로 입증되었다.

* The synergy of ES inferences with physicians and human experts has proved to bring improvement to the diagnosis and treatment processes, both in terms of reliability and efficiency ([Singla et al., 2014](https://www.sciencedirect.com/science/article/pii/S0957417421003419" \l "b0455), [Abu-Nasser, 2017](https://www.sciencedirect.com/science/article/pii/S0957417421003419" \l "b0020), [Rivera Jr et al., 2019](https://www.sciencedirect.com/science/article/pii/S0957417421003419" \l "b0345)).
  + Singla, J., Grover, D., & Bhandari, A. (2014). Medical expert systems for diagnosis of various diseases. *International Journal of Computer Applications*, *93*(7).
  + Rivera Jr, R. F., Pagaduan, R. A., Caliwag, J. A., Reyes Jr, F. C., & Castillo, R. E. (2019, March). A mobile expert system using fuzzy logic for diagnosing kidney diseases. In *Proceedings of the 2nd International Conference on Information Science and Systems* (pp. 161-165).

최근 ES는 전문가의 지원을 넘어 의사결정의 대체자가 되기 시작했다.

* ESs began to be seen not only as an aid to human experts, but also as substitutes ([Ahmed et al., 2019](https://www.sciencedirect.com/science/article/pii/S0957417421003419#b0030)) for a decision making process.
  + Ahmed, A., Al-Masri, N., Abu Sultan, Y. S., Akkila, A. N., Almasri, A., Mahmoud, A. Y., ... & Abu-Naser, S. S. (2019). Knowledge-based systems survey.