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Perspectives

Optimal Safe Staffing Standard for Right Workforce Planning

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The Artificial Intelligence (AI)-driven automated decision-making support system has been heralded as a considerable workforce replacement in the near future by automating mundane repetitive tasks and eliminating time-consuming support tasks in all disciplines (Park & Glenn, 2017). It is no exaggeration to say that such a prediction is already manifesting as reality. The typical example is an application of AI to radiology and pathology in medicine. The Google DeepMind has developed the 'AI Ophthalmologist,' which can diagnose complicated eye diseases in real time (within 30 seconds) (Fauw et al., 2018; see Figure 1) and is currently undergoing commercialization. In the arena of pathology, AI has already shown its potential for cancer detection in differentiating from the precancerous lesion through an improved grading of tumors based on machine learning technology in breast, lung, prostate, and stomach cancers (Niazi, Parwani, & Gurcan, 2019; Chang et al., 2019). Even though a number of practical hurdles in the field of the AI-integrated pathology still exist—which is mainly caused by a higher degree of complexity and specialty of the pathologic diagnosis process—such difficulties are expected to be soon overcome by rapid advances in AI technology.

Accordingly, there is a growing sense of debate that medical AI could cause human doctors to lose their jobs (Lee, 2019). Since the doctoral function that can be replaced by AI is mainly limited to diagnoses at this stage, the opinion that doctors who make good use of AI would have a better chance of surviving seems to be a likely outcome (Lee, 2019). However, a considerable adjustment to the healthcare workforce also seems to be inevitable because healthcare institutions will continue to secure a competitive advantage through an AI's economic efficiency in the fast-paced healthcare industry, even though ethical debates related to commercial exploitation of such technological advances continues (Lee, 2019). It may be safe to say that a re-allocation of human resources is preordained in the AI-integrated healthcare system.

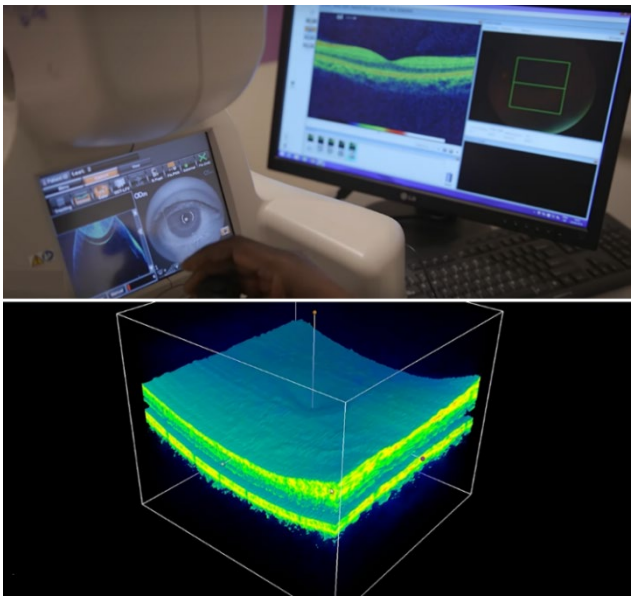


Figure 1. Google DeepMind's AI Ophthalmologist. *Note. Image captured from the DeepMind's "A major milestone for the treatment of eye disease," https://deepmind.com/blog/moorfields-major-milestone/; https://youtu.be/MCI0xEGvHx8

The challenge, then, will be to set up the Optimal Safe Staffing Standard for Right Workforce (Park, 2017) to ensure the best operational effectiveness while also satisfying patient needs, a quotient which will be in high demand as the controversy about the healthcare professional substitution intensifies over time. However, the scientific evidence of the Optimal Safe Staffing Standard for Right Workforce is currently lacking in literature (Park, 2018a, 2018b). To present a real data-driven Optimal Safe Staffing Standard for Right Workforce is thus urgent to maintain human dignity and defend patient safety against possible AI-

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driven pitfalls which would cause health inequity or social injustice (O'Neil, 2016).

We plan to conduct a preliminary study about the Optimal Safe Staffing Standard for Right Workforce in the setting of pathology using Park's Optimized Nurse Staffing [Sweet Spot] Estimation Theory (Park, 2017; Figure 2) within the year. Park's Optimized Nurse Staffing [Sweet Spot] Estimation Theory was developed by a creative synthesis of Nursing Science (Nursing Workforce in Home Healthcare Nursing), Microeconomics (Integrated Production and Cost Function Theory), Mathematical Economics (Duality Theorem), and Advanced Applied Mathematics (Mathematical Programming [Optimization]) (Park, 2017, 2018a). Park's Optimized Nurse Staffing [Sweet Spot] Estimation Theory pinpoints specific, practical, and applicable optimal healthcare safe staffing levels — e.g. (1) an optimal number of physicians or nurses or (2) an optimal composition of the healthcare professionals (physicians + nurses + nursing assistants + AI system and/or care robots)—maximizing quality of care/patient outcomes relative to employment costs in a continuum of change in staffing levels (Park, 2017, 2018a, 2018b). The levels serve as evidence-based informed shared decision-making rationales, which can satisfy all parties constituting our healthcare delivery system—i.e. patients, nurses and/or doctors, and stakeholders—and contribute to the patient-centered value-driven (higher quality yet lower costs) healthcare delivery system reformation (Park, 2017, 2018a, 2018b).

The following multi-site main study will expand its scope and depth of the scientific reach to look for an answer about (1) optimum ranges of patient outcomes (or quality of care outcomes) and (2) optimum ranges of spending, which are required for the healthcare institutions to be included in the Central 'Optimum Nurse Staffing Zone' [ONSZ]—referring to an intersectional Optimum Nurse Staffing Zone among the given multiple model settings (Park, 2018b, p.1232).

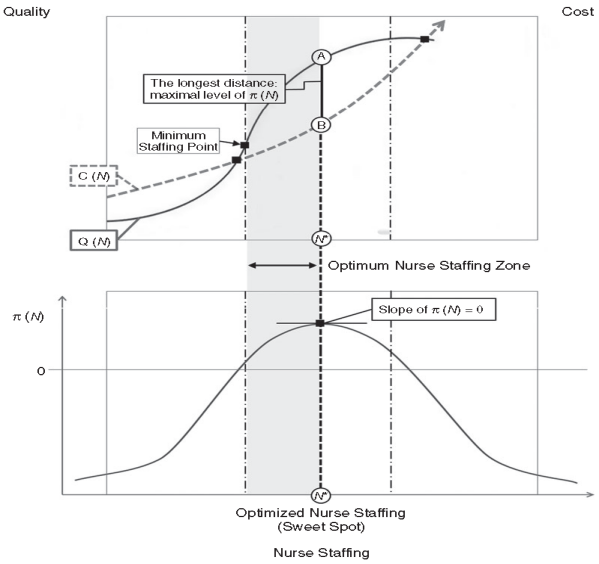


Figure 2 Park's Optimized Nurse Staffing (Sweet Spot) Estimation Theory. *Note*. Park's Optimized Nurse Staffing (Sweet Spot) Estimation Theory is represented by Mathematical Programming (Optimization) (Winston 2004, Rao 2009) based on the 'Duality Theorem in Mathematical Economics' (Diewert 1982, p. 556) with the following functional formula:

$$\text{Max } \{\pi(N) = Q(N) - C(N)\}$$

$$\frac{d\pi(N^*)}{dn} = \frac{dQ(N^*)}{dn} - \frac{dC(N^*)}{dn} = 0$$

[Subject to : function for constraints]

(Q = quality, C = cost, N = nurse staffing)

N^* = Optimal Nurse Staffing, i.e.,'Optimized Nurse Staffing (Sweet Spot)'

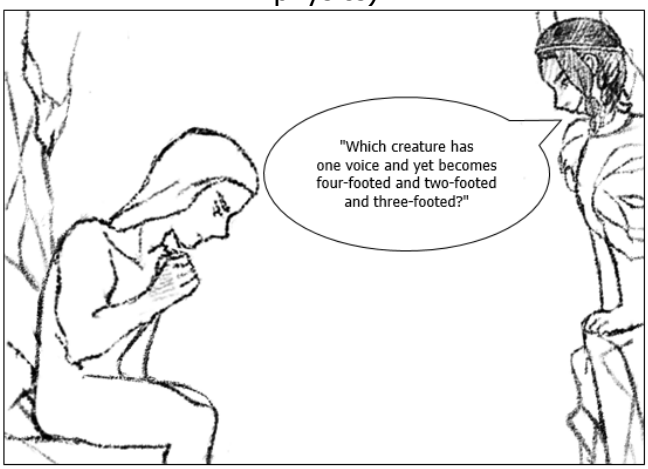
There are two approaches to Mathematical Programming (Optimization): theory-driven and data-driven. For both of them, the specific step-by-step procedures to find the 'Optimized Nurse Staffing (Sweet Spot)' include:

1 transforming values for quality of care into a value of money (i.e., a part of cost-benefit analysis) to make a reasonably comparable unit of Q (N) and C (N);
2 performing curve fittings to determine the real mathematical function formulae of Q (N) and C (N) with the best fit to the actual data (Arlinghaus 1994);
3 calculating "Q (N) minus C (N)" in order to generate the mathematical function formula of π (N), indicating that π (N) also has the best fit to the actual data: i.e., only one X axis for nurse staffing and only one Y axis for the level of π are applied to the theory testing;
4 conducting non-linear mathematical programming (which can be changed) given a set of constraints such as an institution's size, ownership, and the proportion of Medicare patients (Zhang *et al.* 2006) using MATLAB or MAPLE; and,
5 executing global sensitivity analysis to determine the robustness of C (N) to small changes in the values of optimized parameters using Monte Carlo simulations (Saltelli *et al.* 2008).

Figure 2. Park's Optimized Nurse Staffing (Sweet Spot) Estimation Theory**.**

Note. Park's Optimized Nurse Staffing (Sweet Spot) Estimation Theory: Copyright © 2016 Park, Claire Su-Yeon. All Rights Reserved. The figure has been published in the *Journal of Advanced Nursing* under an exclusive license agreement with John Wiley & Sons, Ltd. (see: http://onlinelibrary.wiley.com/doi/10.1111/jan.13284/full). The original copyright has been registered in Korea [C-2016-031091] and in the U.S.A. [TX 8-371-760] with an effective date of 06 Dec 2016; the patent is pending in Korea (Park's User-friendly Cloud-based Intersectional Optimized Nurse Staffing (Sweet Spot) Decision-making Support System [10-2017-0052130] with an effective date of 24 Apr 2017), and the Patent Cooperation Treaty (PCT) patent application claiming priority of the Korean patent application [PCT/KR2018/004660] is pending with an effective date of 23 Apr 2018 (Park, 2017, p.1844). Use of the original contents, illustrations, or ideas in Park's Optimized Nurse Staffing (Sweet Spot) Estimation Theory, either in whole or in part, requires written permission from the copyright/patent holder (Park, 2017, p.1844).

"*Science is not solving problems, but finding problems.*
Scientists are divided by their ability to detect problems."
(Dr. Arno Penzias, 1978 Nobel laureate in physics)



Illustrated by Seobeen Lee

Scholars are not Oedipus solving a riddle but the Sphinx posing one.

Figure 3. Our Role as Scientists.

Creative imagination is highly valued in the era of the fourth industrial revolution. Accordingly, interdisciplinary or multidisciplinary research is necessary to create the new, innovative, and viable solutions that will address the complexity of our social problems. We commonly think that such multidisciplinary research would progress nicely once various experts got together. This is simply not true. The fact that most of their research outcomes do not produce new knowledge systems but are instead merely a compilation supports this statement.

We have developed a program of research based on the already well-established theory, Park's Optimized Nurse Staffing [Sweet Spot] Estimation Theory (Park, 2017), which functions as a metatheory—a well-suited bridge between disciplines. We thus believe that our endeavors to affect the future of workforce policy-building and decision-making practice through this evidence-driven win-win cooperation among concerned parties will cause a cascade of positive change within the health community.

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