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The Technical Underpinnings and Extended what-if Analyses of the Decision Support Systems Programmed for the IOM 80/20 Nursing Initiative

Authors: **Edward J. Lusk**, Professor of Accounting, The State University of New York (SUNY) at Plattsburgh, School of Business and Economics: Plattsburgh, NY, USA and Emeritus, Department of Statistics The Wharton School, University of Pennsylvania, Philadelphia, PA, USA, lusk@wharton.upenn.edu, luskej@plattsburgh.edu, **Christine T. Kovner**, Professor of Nursing, New York University, College of Nursing New York, NY, USA, Christine.Kovner@nyu.edu, **Chuo-Hsuan Lee**, The State University of New York (SUNY) at Plattsburgh, School of Business and Economics: Plattsburgh, NY, USA, leeca@plattsburgh.edu, **Carina Katigbak**, New York University College of Nursing, New York, NY, USA, carina.katigbak@nyu.edu, **Nellie Selander**, Consultant: New York University College of Nursing, New York, NY, USA, nms337@nyu.edu

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One of the goals of the Institute of Medicine's (IOM) initiative: Analysing the Cost of Alternative Strategies Related to Nursing Education is to re-organize the nursing workforce in the United States so that after a relatively brief time, ten years or so, eighty per cent of the nursing workforce will consist of nurses with a Bachelor of Science in Nursing degree while, then by definition, the remaining twenty per cent will be Associate Degree &Diploma nurses. [The 80/20 Initiative].To aid health planners to create the information to develop the policies needed to effect The 80/20 Initiative Kovner, Lee, Lusk, Katigbak &

Selander (2013) developed two Decision Support Systems [DSS]: The SWAP: DSS and the Dynamic Change: DSS. In this companion communication, we elaborate on the construal overview presented by Kovner et al. (2013). Specifically, we: (1) present the technical details of The SWAP and The Dynamic Change DSSs, (2) prove that the SWAP benchmark is the least expenditure alternative, and (3) offer extended "What-If" analysis enrichments useful in summarizing the voluminous decision information that could be generated by these DSSs. Presenting these critical technical details on the functionality of these DSSs will create the synergistic transparency needed to encourage the use of these DSSs by health planners.

Keywords: *Extended What-If Elaborations; Swapping; Dynamic Change*

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Introduction: The Point of Departure of the Study

The powerful computing technology in the modern world has facilitated the creation and application of Decision Support Systems (DSS). The spectrum served by the contemporary DSS is extensive. At one end, it may simply represent data links that provide summaries of data streams with General User Interfaces (GUI) support linked to SAS™, Excel™, or Word™ display platforms. At the other end of the same spectrum, it might actually refer to complicated integrated interactive networked GUIs that generate expert systems information to be considered by the DM. An example of the latter is the remarkable IBM™ Jeopardy™ "Contestant" Watson who soundly defeated Ken Jennings and Brad Rutter, the two most successful Jeopardy champions of all time, in a live head-to-head two- game match where the prize for winning was $1,000,000 (Borenstein and Robertson, 2011).In the simple gaming world, the Tick-Tack-Toe DSS engineered by Bell Labs and installed in the 1950s at the Museum of Science & Industry in Chicago, Illinois USA retired undefeated after entertaining hopeful school children for decades. DSS have won world chess championships; Deep Blue, again of IBM, in 1997 dispatched a disgruntled Kasparov, the reigning world chess champion for 15 straight years (seeJayanti, 2003). This is an impressive record given that computers started life as simple "2 + 2" calculators circa 1947.

In a DSS context, a What-If analysis is the re-parameterization of key or sensitive variables so as to re-generate the DSS information aloud put. A What-If analysis is an important aspect of using the DSS in arriving at a final decision. It allows DMsto engage in "sensitivity analysis"; that is, consider various "alternative" parameterizations and the results that they may produce for decision making.

Kovner, Lee, Lusk, Katigbak & Selander (2013) developed DSSs and used What-If analyses to help health planners explore the impact of their various anticipated options to arrive at an acceptable way to strive for the IOM 80/20 Initiative. The Institute of Medicine's (IOM) Committee on The Future of Nursing to: "increase the proportion of nurses with a baccalaureate degree to 80% by 2020" to arrive, after a planning horizon of 10 years, at a workforce of eighty percent registered nurses (RNs) with a Bachelor's Degree in Nursing (BSN) and twenty percent with an Associate Degree or a Diploma certification (AD-D). [The 80/20 Initiative]

The conceptual overview of these DSS as presented by Kovner et al. (2013) necessarily addressed the general concepts used in the DSS montage. To complete the expression of these DSS, we offer in this companion paper the technical underpinnings of these DSS. We feel that to understand the technical dimensions of these DSS is critical to promoting their use by health planners. This is another way of saying that the devil is in the details—i.e., a rich understanding of the detailed nature of a DSS is a necessary condition to their use. This is the point of departure of our paper.

In the following pages we will:

1) Present and discuss, as an operational context for the technical presentation, the two DSS, which were developed to help health care workforce planners evaluate the expenditures required to achieve The 80/20 Initiative.
2) Justify benchmarking in this operational context and offer a novel approach to benchmarking using an assumption of total RN workforce stasis and direct trading (e.g., swapping AD-D RNs to create the additional BSN-prepared RNs needed in the workforce) which would require: (1) enrolling AD-D prepared RNs in BSN programs and ensuring that they graduate, and/or (2) shrink the AD-D workforce and increase initial enrollments in BSN programs.
3) Demonstrate the DSS functionality and show mathematically, that swapping requires the fewest number of conversions—AD-D to BSN RNs. Therefore, the Swap number will serve as a good benchmark to evaluate proposals made by the DM to achieve The 80/20 Initiative.
4) Offer a What-If context for the DSS analysis, and extend the What-If analyses to a best-average-worst case scenario calibration, where the expectation model is used to form a synthesis of these analyses.

General Context of the 80/20 Robert Wood Johnson Foundation IOM Funding Initiative

The following question is raised by The 80/20 Initiative:

Is The 80/20 Initiative feasible and, if so, what are the expenditure consequences of achieving such a dramatic reorganization of the RN workforce?

To generate such information and to provide DMs with sufficient flexibility to test various What-If assumptions, we created a DSS, composed off our principal worksheet modules. Each worksheet is organized around the concept of decomposition—i.e., where DMs indicate the various important elements of the information set for the particular worksheet. Then, the DM enters the elemental or decomposed information, which is then aggregated and transferred to the next worksheet. For a rich discussion of decomposition see: Lee & Anderson (2001), MacGregor (2001), Kester, Kirschner & van Merrienboer (2005), and Adya, Lusk & Belhadjali (2009). Consider now these four Excel™ worksheets and their elements as described in detail by the Dynamic Change and SWAP DSS manuals offered by Kovner, Katigbak and Selander (2013a,b).

- Worksheet I: Baseline Workforce Information. To start the process of developing information the DM at a particular location context estimates he number of BSN and AD-D RNs currently in the nursing workforce. The DSS then calculates the number of BSN and AD-D nurses in these workforces and transfers this information to the next worksheet.
- Worksheet II: Required Number of BSN RNs Needed over What Would Occur Normally—based upon historical projections. This is the most critical worksheet in the DSS. However, there are two different concepts under which this required number of BSN is developed. The first, as introduced above, is the SWAP of AD-D to increase the number of BSN RNs; essentially this is a conversion of AD-D RNs to BSN through the Nursing Education System [NES]. This swapping is relatively simple and does not require extensive parameterization by the DM. The second DSS, the more usual context, is where the numbers of AD-D and BSN RNs will be changing over the planning horizon. We call this the Dynamic Change: DSS in contrast to the SWAP: DSS. The SWAP: DSS serves as a benchmark; it assumes that (I) there will be stasis with respect to the size of the total nursing workforce, and (ii) the increase in the number of BSN needed to satisfy The 80/20 Initiative occurs as a 1-to-1 reduction of the number of AD-D nurses. In contrast, the Dynamic Change: DSS relaxes the SWAP assumptions and allows for changes in the BSN and AD-D workforces, and so in the total nursing workforce.
- Worksheet III: Feasibility. Given the number of BSN that need to be produced by the NES to achieve The 80/20 Initiative, either under the SWAP or the Dynamic Change contexts, this worksheet module assesses the systemic feasibility of adding this required number of

BSN. This assessment requires the DM to use the data from Worksheet II to estimate the following elements:

a) The number of BSN RNs that currently graduate from select types of nursing education programs in the location context that the DM is analyzing, and
b) The possible increase in such BSN RNs graduates given assessments of the NES resources in the location context.

- Worksheet IV: Expenditure Consequence of the 80/20 Policy. In the practical context within which this Dynamic Change: DSS will be used, the focus is on the price to be charged—i.e., the expenditure needed to achieve The 80/20 Initiative. This expenditure basis may also be viewed as the cost/resource commitment agencies must make, which have the intention to create the individual policies necessary to realize The 80/20 Initiative. Given this final determination of the number of BSN RNs needed, as developed in the previous Feasibility section of the DSS, the practical expenditure expectation of achieving the ratio of BSN to AD-DRNs can then be computed. Thereafter, the DM will select the feasible and reasonable number of BSN RNs expected for the purpose of estimating the resources needed to achieve this number of BSN RNs at the end of the planning horizon. This will be the final computational stage of either the SWAP: DSS or the Dynamic Change: DSS.

Stasis Benchmarking: Finding a Reasonable Basis of Comparison for the Dynamic Change: DSS

Given the four sequential building blocks of the Dynamic Change: DSS, the next issue to be addressed is selecting a benchmark for the expenditure needed to achieve The 80/20 Initiative using the Dynamic Change: DSS. The "benchmarking issue" is that while it is true that the DM estimates will eventually culminate in a final expenditure of achieving The 80/20 Initiative hat expenditure will not have an "obvious" relative comparison because the expenditure consequence computation is the unique expression of a particular DM who is projecting to the end of the planning horizon. In contrast, it is almost exclusively the case that reports from government agencies such as: US Department of Health and Human Services [DHHS], Social Security Administration [SSA], Organization for Economic Co-operation and Development [OECD], or The World Health Organization [WHO] which are usually summary of the historical past and not future projections, and so, are not likely to be reasonable benchmarks to projections from the workforce information created by the four components of the Dynamic Change DSS. For this reason, to develop such a focused and meaningful expenditure comparison, we propose using the expenditures developed under the SWAP context by the same DM who is now evaluating the Dynamic Change DSS as the benchmark of the expenditures projected by the Dynamic Change's. Additionally, as we shall prove subsequently, the SWAP conversion will always be less than the number of BSN RNs needed under the assumptions of the Dynamic Change: DSS and therefore provides a focused and meaningful relative benchmark given their unique parameterization of a particular DM. Next we will present, in detail, the logistical organization of the detailed information in these two DSS.

Dynamic Change Projections and SWAP-Stasis Benchmarking: The Underlying Details

All of the feasibility and expenditure information is developed from the progenitor calculations of the worksheet module: Required Number of BSN RNs Needed over What Would Occur Normally. Assuming that the total RN workforce at the baseline year is:

$$A+B$$

Where: A and B respectively represent the numbers of AD-D and BSN RNs licensed to practice in the regional workforce at the baseline year,

At the end of the planning horizon the numbers are projected/estimated/assumed to be:

Eq 1: SWAP: Context $\hat{A}+\hat{B}=A+B$

Eq 2: Dynamic Change: Context $\tilde{A}+\tilde{B}$

Where : $\hat{B}=B+\Delta B\_SWAP$, $\hat{A}=A-\Delta B\_SWAP$; therefore $\hat{A}+\hat{B}=A+B$. And for Eq 2 we have $\tilde{B}=B+\Delta B\_DC$, $\tilde{(A)}=A+\Delta A\_DC$,

:ΔB_SWAP, ΔA_DC, ΔB_D Care the changes in the number of AD-D and BSN for the respective SWAP and Dynamic Change DSS occurring over the planning horizon,
:further, ΔB_ SWAP , ΔA_DC , ΔB_D Care likely to be in the related practical intervals: [-B to (2 x B)]and [-A to (2 x A)].This just means that (i) the reduction in the workforce cannot be equal to or greater than the workforce size at the baseline and (ii) the size of the workforce is not likely to double over the planning horizon; it should be noted that the DSS will accept any reasonable parameterization which produces expected values of the change in A or B. we will be working in this usual context for all the illustrations and demonstrations following.

These changes may lead to the following ratios at the end of the planning period:

Eq 3 SWAP BSN Ratio: $\frac{\hat{B}}{B+A} = 0.8 - \delta$

Eq 4 Dynamic Change BSN Ratio: $\frac{\tilde{B}}{\tilde{A}+\tilde{B}} = 0.8 - \delta$

Where: δ is in the open unit interval: 0 <δ< 1. This means that the projection at the end of the planning horizon is expected to result in a shortfall of the numbers of BSN-RNs needed to achieve the 80/20 policy goal. The shortfall is, of course, the only condition of interest in the DSS context because if the final ratios at least satisfy the 80/20 policy goal, then no DM actions would be warranted. The shortfall is noted as δ and is in decimal rather than percentage notation. For example, if δ were to be .25 this would mean that the number of BSN as a ratio to the size of the workforces was .55 and so there was a shortfall of 25% of reaching the 80/20 policy goal.

If Eq 3 and 4 are used and there is a positive δ, this means that there will be a shortfall in both the SWAP and Dynamic Change contexts. Implication: B_ s^ε must be added to the number of BSN in the workforce for the SWAP context, and B_ DC^ε must be added to the BSN workforce in the Dynamic Change context during the planning period to satisfy the policy goal. These relationships script out as follows:

Eq 5 Policy Achieving State: SWAP $\frac{\hat{B}+B_S^{\varepsilon}}{[B+A]}=0.80$

Eq 6 Policy Achieving State: Dynamic Change $\frac{\tilde{B}+B_{DC}^{\varepsilon}}{[\tilde{B}+B_{DC}^{\varepsilon}]+\tilde{A}]}=0.80$

The respective solution values of B_ s^ε and B_ DC^ε is:

Eq 7 $B_S^{\varepsilon} = \delta \times [B + A]$

Eq 8 $B_{DC}^{\varepsilon} = 4\tilde{A} - \tilde{B}$

In order to demonstrate the correctness of the above theoretical solutions in Eq. 7 and Eq. 8, it would be value able to give two examples taken from pilot information for the two DSS.

Relative Numbers under Stasis and Dynamic Change

Example 1:

From one of the pilot tests of the launched DSS system, the number of BSN and AD-D RNs estimated at the baseline year of 2012 were: 152,660 and 124,178 respectively. This gives, under the stasis assumption of the SWAP: DSS, a total workforce at 2012 and also at 2021(the end of the ten year planning horizon) of: 276,838. The BSN-ratio of interest is:

$$\frac{152{,}660}{152{,}660+124{,}178}=55.14\%$$

As the policy goal is 80%, the value of the short-fall, δ, will be: δ=0.80-0.5514=.2486. Therefore, according to Eq 7, the number of BSN nurses to be Swapped is:

$$B_S^{\varepsilon} = \delta \times [B + A]$$

$$B_S^{\varepsilon} = .2486 \times [152{,}660 + 124{,}178] \text{or}$$

$$B_S^{\varepsilon} = 68{,}810.$$

The demonstration proof of this calculation is:

$$\frac{152{,}660+68{,}810}{[152{,}660+68{,}810]+[124{,}178-68{,}810]}=80\%$$

Or

$$\frac{221{,}470}{[221{,}470] + [55{,}368]} = 80\%$$

This means that over the planning horizon there must be a reduction in the number of AD-DRNs and an exact increase of BSN RNs—i.e., a SWAP of 68,810 RNs. The policy implications of this are likely to be complicated, to say the least, and may ultimately need to be legislated either directly or indirectly. In any case, underlying the SWAP context is the assumption of extensive and relatively absolute control of the NES. Therefore, as a final summary, to meet The 80/20 Initiative there must be 68,810 new BSN RNs added to that workforce so arriving at 221,470 BSN RNs where the total workforce is assumed to remain the same as it was at the baseline year—i.e., stasis of 276,838.

Example 2:

For the Dynamic Change DSS, using the same baseline numbers from a pilot test, and the belief that the actual growth rates will be 10% for the BSN RNs and 5% for the AD-D RNs the number of RNs estimated at baseline in the two categories are:

BSN [152,660] and AD-D [124,178] respectively giving the same BSN ratio as noted above:

$$\frac{152{,}660}{152{,}660 + 124{,}178} = 55.14\%$$

In this case, the individual who was piloting this DSS for their location context assumed that the BSN workforce would grow on net by 10% and the AD-D workforce will grow on net by 5%. Applying the future value concept by compounding the future value annually using these specified growth rates , at the end of the planning horizon, the DSS projects: 395,961 BSN and 202,273 AD-D RNs to be the workforce at the end of the planning horizon. This gives the BSN-ratio of:

$$\frac{395{,}961}{395{,}961 + 202{,}273} = 66.2\%$$

In the Dynamic Change case, the numerator and the denominator will both be changing. Using Eq 8:

$$B_{DC}^{\varepsilon} = 4\tilde{A} - \tilde{B}$$

The additional number of BSN needed will be:

$$B_{DC}^{\varepsilon} = 4 \times 202{,}273 - 395{,}961$$

or

413,131 BSN RNs will be needed.

This result is also simple to prove as one can see from this demonstration calculation:

$$\frac{395{,}961 + 413{,}131}{[395{,}961 + 413{,}131] + 202{,}273} = 80\%$$

This result means that assuming the projections are accurate, the number of new BSN that must be added, in addition to the projected incremental increase, is 413,131! This number of new BSN (i.e., 413,131) needed under the Dynamic Change DSS is as six times as the 68,810 of new BNS needed under the stasis assumptions of SWAP DSS.

Of course, one may suppose, as the total force under the SWAP assumptions was held constant and the relative workforce numbers under the dynamic change perhaps were increasing it is to be expected that the SWAP would be lower. In order to establish this supposition one needs to prove that under the SWAP assumptions, the number of BSN RNs needed is always lower in the practical context of the nursing workforce.

Swapping: The Minimal Logical Benchmark

We are interested in determining the magnitude of the relationship between the numbers of nurses holding a BSN needed to satisfy the 80/20 policy goal under the two different contexts: The SWAP and The Dynamic Change, as defined above. It is of interest to determine if the number of BSN RNs needed to be added by the NES under the SWAP assumptions is always lower than that under the Dynamic Change assumptions. The SWAP results will serve as an excellent benchmark for the expenditure required to achieve the policy goal under the assumptions of the Dynamic Change context. To test for the minimum number relationship under the two contexts consider the following initial or projected and final context specific state profiles:

Swap Context:

Eq9 Projected end-state $\frac{B}{B+A} = 0.8 - \delta$

Eq 10 Desired end-state $\frac{B+\Delta B}{(B+\Delta B)+(A-\Delta B)} = \frac{B+\Delta B}{B+A} = 0.8$

Dynamic Change Context:

Eq11 Projected end-state $\frac{B}{B+A} = 0.8 - \delta$

Eq12 Desired end-state $\frac{B+\Delta B^*}{(B+\Delta B^*)+(A-(\Delta B-1)} = 0.8$

Where

: δ represents the general shortfall in achieving the policy goal and is the same for both the SWAP and Dynamic Change contexts at the baseline time when Eq 9 Eq11; δ is therefore:0<δ<1.

: ΔBand 〖ΔB〗 ^*represent the number of BSN added to the workforce that results in achieving the policy goal in the SWAP and the Dynamic Change contexts respectively. i.e., these numbers of BSN drive the respective short falls, δ, to zero.

: The policy goal will be noted as: γ/(1-γ). For the IOM initiative, γ is the label reserved for the desired percentage of BSN in the total workforce at the end of the planning period, specifically: γ= 80% ; so, then, (1-γ) is the label for the percentage of AD-Diploma nurses in the total workforce.

To test whether the SWAP or the Dynamic Change has the minimum number of BSN needed to satisfy The γ/(1-γ) Policy Goal we opted for a simple minimal directional test as the numbers of BSN and AD-D are discrete integers. Therefore, given this election, we used, for the Dynamic Change context, as the change in A: one more AD-D than is the reduction under the SWAP context; this is noted in Eq12 as: (A-(ΔB-1). Simply, if Eq 12 used ΔBas the reduction in AD-Diploma nurses, then Eq 12 would be identically Eq 10 and the numbers of BSN needed would be the same in both contexts. This is another way of saying that this is the point of departure for the test of interest—i.e., the point at where the SWAP and Dynamic Change are identical. We then move off this point of equilibrium identity in the Dynamic Change context by the smallest increment possible i.e., one AD-Diploma nurses more than in the SWAP context.

Given, the above, the question of interest is:
What is the magnitude relationship between the numbers of BSN in the two differences contexts?

Examination of the magnitude relationships between the SWAP and the Dynamic Change Contexts

If one solves Equations: Eq 9 and Eq 10 for the change in the BSN,ΔB, needed to achieve the policy goal, that is, to increase the number of BSN to the point where the ratio of BSN in the workforce is 80% for which, therefore, δ=0, then the following will be the result:

For the SWAP context: ΔB= δ× [B+A].

For the Dynamic Change context, if one subtracts Equation Eq 11 from Eq 12 to solve for the change in the BSN,ΔB^*, needed to achieve the policy goal in the Dynamic Change context we find:

Eq12 less Eq11 gives:

Eq13 $(1-\gamma)\Delta B^* = (1-\gamma)\Delta B + \gamma$

We can reform Eq13 as:

Eq14 $\Delta B^* = \Delta B + \gamma/(1-\gamma)$

Therefore, it is immediate that $\Delta B^* > \Delta B$ as: $\frac{\gamma}{1-\gamma} > 0$.

Therefore, as one moves off the point of equilibrium where Eq9 Eq 11 by the minimal increase in the number of AD-Diploma nurses (i.e., 1) at the end of the planning horizon in the SWAP context, the number of BSN needed in the Dynamic Change context is always greater than it would be in the SWAP context. This is what the equations indicate—in particular Eq14.

It may be instructive to illustrate the relationships presented in Eq 14 with a simple example. To do so we must relax the strict stasis and SWAP trade-off assumptions of the SWAP context so as to make a comparison with the Dynamic Change context. Specifically, we will allow the total workforce to grow by only an increment in the BSN workforce with no reduction in the

AD-Diploma workforce. This modification in the SWAP context will be necessary as there is no way to directly compare the two contexts as they are by definition incompatible—i.e., the SWAP context precludes the Dynamic Change context.

Preamble to the illustration we will first compute the number of BSN needed to achieve the exact 80% policy goal in the Dynamic Change context starting from the SWAP results and then search starting at one additional BSN in the modified SWAP context to arrive at the exact ratio of 80%.

Illustrative Computations for the Context of the Minimum SWAP Proof

Using the pilot test information as noted above, at baseline, we find the ratio of BSN to be:

$$\frac{152{,}660}{152{,}660 + 124{,}178} = 55.14\%$$

Therefore using Eq 7

$$B_s^{\varepsilon} = \delta \times [B + A]$$

We find that the number of BSN needed to be added under the SWAP context is

$B_s^{\varepsilon} = .2486 \times [152{,}660 + 124{,}178]$or $B_s^{\varepsilon} = 68{,}810$.

The addition of the 68,810 BSN results in a policy ratio of:

79.9999%: (152,660 + 68,810)/[(152,660 + 68,810) + (124,178 –(68,810))] x 100.

In this case, let us look at the Dynamic Change where NOW we increase the number of AD-D nurses by one. This results in the following policy ratio:
(152,660 + 68,810)/[(152,660 + 68,810) + (124,178 –(68,810 -1))] x 100 =

79.9996%

We solve, using Eq 8: B_DC^ε= 4A˜-B˜ for the number of the BSN needed to achieve 80%.

Here: $\tilde{B}$= (152,660 + 68,810) = 221,470 and

$\tilde{A}$ = (124,178 – (68,810 − 1)) = 55,369, so

$B_{DC}^{\varepsilon} = 4\tilde{A} - \tilde{B}$ is: 4 × 55,369 – 221,470 = 6.

This means to achieve The 80/20 Policy Goal, six (6) more BSN need to be added to the BSN workforce and of course to the total workforce.

Therefore, we have
(152,660 + 68,810 + 6)/ [(152,660 + 68,810 + 6) + (124,178 –(68,810 –1))] = 0.8 exactly.

Now let us return to the SWAP example, and make the changes needed to achieve exactly achieve The 80/20 Policy Goal. Recall for the SWAP the addition of the 68,810 BSN results in a policy ratio of:
79.9999%: (152,660 + 68,810)/[(152,660 + 68,810) + (124,178 –(68,810))] x 100

First we added 1 BSN. However, the achieved ratio is less than 80%. Next we add 2 to the BSN group and so add two to the total workforce, and left the AD-Diploma group the same and now we have the following exact ratio:

Modified SWAP:

$$\frac{152{,}660 + [(68{,}810) + 2]}{152{,}660 + [(68{,}810) + 2] + (124{,}178 - (68{,}810))} = 0.80$$

Compare this to the Dynamic Change:

(152,660 + 68,810 + 6)/ [(152,660 + 68,810 + 6) + (124,178 – (68,810–1))] = 0.80

The exact relative integer change for the Dynamic Change is 4 [6 – 2] more units as ones move off the equilibrium point 68,810.

In summary, in the Dynamic Change context if we want to add 1 AD-Diploma nurse to move off the equilibrium point then six (6) BSN must be added to achieve the exact 80% ratio, whereas in the modified SWAP context as presented above where the AD-Diploma reduction of 68,810 is firm but we need to have an exact 80% ratio, only two (2) BSN needed to be added to the BSN workforce to achieve the exact 80% policy goal. This demonstrates with a numerical example the equation relationships scripted out in Eq14 where we show that number of BSN needed to be added in the SWAP context are always less than in the Dynamic Change context—i.e.,

Eq14 $$\Delta B^* = \Delta B + \gamma/(1-\gamma)$$

So $$\Delta B^* > \Delta B \text{ as: } \frac{\gamma}{1-\gamma} > 0.$$

As indicated above, the SWAP context requires fewer number of BSN to be added to the workforce than that required by the Dynamic change context. Therefore, assuming that the NEC resources would be used in proportion to the number of BSNs added it is intuitive to develop the following:

The expenditures under the SWAP conditions will be lower than under

the Dynamic Change conditions.

Since we have justified the SWAP as a logical benchmark, now we recommend a summarizing statistic called the Expenditure Benchmark (EBM) as a tool to explore the impact of the 80/20 initiative on expenditures of the NES.

The EBM: A Ratio of Effort to Benefit

Now that the DM has calculated the two numbers of BSN needed to satisfy The 80/20 Initiative, the DM can logically benchmark the Dynamic Change result with the SWAP results developed above. Recall that there are two different numbers of BSN that would achieve The 80/20 Initiative in our previous two examples. Specifically, under the Dynamic Change (where the growth in the BSN was assumed to be 10% and the growth in the AD-D workforce was expected to be 5%) 413,131 new BSN were needed; while under the SWAP (where the increase in the BSN comes as a reduction of the ADD-D workforce) only 68,810 new BSN are needed. To highlight the usefulness of the SWAP information as a benchmark, we recommend computing the following ratio which we call the Expenditure Benchmark Multiplier [EBM]:

$$EBM\colon \frac{\text{Expenditure under Dynamic Change}}{\text{Expenditue under SWAP}}$$

Or

$$EBM\colon \frac{\text{Number of BSN Needed Under Dynamic Change}}{\text{Number of BSN Needed Under SWAP}}$$

In this case for the EBM benchmark, because the DM is allocating the number of BSN RNs needed in the SWAP [68,810] and Dynamic Change [413,131] to the expenditure worksheet in equal proportions the Expenditures and the Number ratios will be the same. In this case, using the latter numbers relationships, the EBM ratio is:

$$EBM\colon \frac{414{,}131}{68{,}810} = 6.0$$

Or

$$EBM\colon \frac{\$7{,}417{,}938{,}752}{\$1{,}232{,}528{,}755} = 6.0$$

This important information is that here in we can clearly see the effect of not having the authority, ability or willingness to effect the necessary changes in the NES to expeditiously reach The 80/20 Initiative by swapping. If one simply lets the BSN and the AD-D RN workforces grow at 10% and 5% per year respectively, at the end of the planning horizon the number of BSN needed to reach the policy goal will require expenditures about 6 times the expenditure under the control assumptions of the SWAP. Here we are using the relative numbers under the SWAP and the Dynamic Change contexts rather than the expenditures under each context as the expenditures are a constant multiplier for each context.

As a result, the DM has now collected two critical pieces of information:

The Dynamic Change: DSS output is that the expected expenditures of 7.4 Billion will be needed to realize The 80/20 Initiative,

The Expenditure multiplier for not controlling the NES is about six times the SWAP expenditures of$1.2 Billion.

With this EBM ratio information we recommend that the DM conduct What-if analyses to develop alternative BSN scenarios and then "price" them. Let us now offer a few illustrative examples of What-If analysis and then extend this concept to re-coding the what-if concept as: Best, Average/Usual and Worst Case scenarios.

What-If Alternatives: Converging to a Possible Reality

What -If Analyses. For the case under consideration, re-calibrating the DSS is necessary as the number of BSN needed may require such a high level of expenditure that it is not political feasible. In this case, the DM is searching for a redistribution of the needed numbers of BSN nurses in order to bring the expected expenditures down into the politically feasible range. For example, given the current Fiscal Cliff expected eventualities [see WSJ (2013)], the DM may believe that the projected expenditures of $7.4 Billion, as illustrated above cannot possibility be funded considering that governments are unable to fully fund education budgets. In this case, the DM recognizing that on-line programs require the lowest expenditure of resources, could allocate all of the students to on-line programs to save resources in order to possibly achieve The 80/20 Initiative. In this case, the EBM will remain the same BUT the total expenditure will change. Therefore, the DM will create a What If expenditure that hopefully will be sufficiently low to satisfy the political scrutiny of the needed expenditure.

For example assuming that all the BSN under the two different contexts are generated from On-Line programs as the What-If analysis then the relative changes are presented in Table1 following:

Table 1: The 100% On-line What-If-Analysis Scenario for the SWAP Benchmark and the Dynamic Change

Pricing Scenarios	**100%** of SWAP Expectation	**100%** of Dynamic Change Expectation
Number of BSN-Prepared Nurses	**68,810**	**414,131**
Total Expenditures	**$723,468,555**	**$4,354,174,624**

Here using the expected expenditures of this What-if-Analysis, the overall expenditure is now reduced to about 60% of the initial projection [$4,354,174,624/$7,417,938,752 = 58.7%]. Also, recognize that the EBM remains the same as all the BSN came from the same on-line programs—e.g.

$$EBM\colon \frac{\$4{,}354{,}174{,}624}{\$723{,}468{,}555} = \frac{414{,}131,}{68{,}810} = 6.0$$

After the online programs are adopted, the statistical profile would become:

1) The Dynamic Change: DSS output is that the expected expenditures of $4.4 Billion will be needed to realize The 80/20 Initiative,
2) The Expenditure multiplier for not controlling the NES is still about 6 times the SWAP expenditure.

Now, the DM has the lowest expenditure possibility—i.e., using only the on-line alternatives where the expenditure is $4.4 Billion. Let us assume that this option of using online programs is still outside the politically feasible range given the economic climate. Continuing with the What-If analysis, the DM can now evaluate the possibility of influencing the NES where The 80/20 Initiative is possible. This is where the EMB ratio provided critically important information.

The EBM: A Prompt to the DM

Continuing our discussion from above the 100% On-Line alternative with the lowest costs under the Dynamic Change context of an expenditure of $4.4 Billion is, in the world of the Fiscal Cliff (Postal & Festa, (2013)), still too large to garner the political support. The EBM suggests that since this $4.4 Billion under the Dynamic Change context is 6 times larger than the expenditure under the SWAP mode the best cost-saving way to achieve the 80/20 Initiative is to directly go for the SWAP option where only 68,810 BSN would be needed. Although the SWAP option is a theoretically lowest-cost option, to swap AD-D to BSN on a one-on-one ratio would require a strong level of control of the NES that is unlikely to be possible. Despite the difficulty to pursue a SWAP option with the most cost-saving, there may be a "compromise" solution. This is where the "prompt" nature of the EBM comes into play. For example, let us assume that according to the estimate of the DM a budget of $1.7 Billion or about40% of the Dynamic Change expenditure is most likely to be politically feasible. Now prompted by the EBM that indicates that $1.7Billion is less than 6 times of the SWAP expenditure of 724 Million[$1.7Billion/724Million= 2.4 times], the DM understands that 1.7 billion is a limited resource and would take action to calculate the total number of BSN that an expenditure of $1.7 Billion can help the NES to create. In this case, using only the On-Line programs as parameterized from the pilot test where the total average cost per BSN over the four year program including related costs is $10,514the DM find that 1.7 Billion could produce 161,689BSN nurses [$1.7 Billion/$10,514]. At this point, the DM realizes, through the EBM prompting, that there may be an alternative solution located in the spectrum between the SWAP and the Dynamic Change options, which is a “Blend” of the Dynamic Change option in which the agency has no control of the NES and SWAP option which requires a total control of the NEC. This alternative solution may offer a way to strike a political feasible expenditure that would support the IOM 80/20 initiative.

Given the information provided in Example 1, there are152,660 BSN and 124,178 AD-D nurses available at the baseline year. Instead of adding 161,689 BSN by spending 1.7 billion dollars through 100% On-Line Programs the DM may investigate the possibility to add only a portion of the 161,689 BSN to the baseline figure of BSN and, simultaneously, reduce a portion of the number of AD-D nurses from its baseline figure.

Assume that the percentage of the 161,689 BSN to be added is α, and the percentage of the AD-D nurses to be reduced is also α. Then, the DM may solve for α in the following Prompt-relationship:

Eq 15 $$80\% = (152{,}660 + \alpha\,[161{,}689]) \,/\, [(152{,}660 + \alpha\,[161{,}689]) + [(1 - \alpha) \times [124{,}178]]]$$

Where: α is the exact percentage needed to achieve the 80/20 Initiative assuming that there is a reduction in the AD-D nursing population. This prompt equation creates a balance where given the possibility to add BSN, in this case, some proportion of 161, 689 will be added to the BSN and some proportion of the AD-D workforce will be reduced. This is to say just adding the 161,689 BSN alone will not result in achieving the 80/20 Initiative. For example, the following ratio fails to achieve the 80/20 goal:

$$\frac{152{,}660 + [(161{,}689)]}{152{,}660 + [(161{,}689)] + (124{,}178)} = 0.72$$

This of course means that merely adding to the BSN in this case cannot bring the ratio relationship between the BSN and AD-D workforce into line with the 80/20 Initiative without a reduction in the AD-D workforce.

In this case, α = 52.26%; this indicates that 84,492 BSN are needed [.5226 × 161,689] and the number of AD-D that need to be converted—i.e., the reduction in the AD-D workforce—is 64,890 AD-D [.5226 × 124,178].The demonstration proof is:

$$\frac{152{,}660 + 84{,}492}{152{,}660 + [(84{,}492)] + (124{,}178 - (64{,}890))} = 0.80$$

Now, the DM realizes that it is possible to satisfy the IOM 80/20 Initiative by adding only 52.26% of the 161,689 BSN given that a simultaneous 52.26% of reduction in the AD-D workforce can be enforced by the health policy.

The general form of the conditional equation for determining this information is:

Eq 16

$$80\% = \frac{B + \ \alpha(\Delta B)}{B + \ \alpha(\Delta B) + (1 - \alpha) \times (A)}$$

Where:

B and A are the baseline estimation of the number of the BSN and the AD-D respectively,

: Δ B is possible number of BSN that could be added given the estimated political reality of a particular expenditure. For example, the $53.5 Million in the example presented above.

: α represents the percentage of ΔB that are needed to be added to the BSN workforce from the baseline number, B, and simultaneously that the number of AD-D at baseline, A, is reduce to $(1 - \alpha) \times A$. If the baseline ratio < 80% then it is immediate that $0 < \alpha < 1$.

In this case then, the DM learns that the actual resources needed to train 84,492 (i.e., 52.26% of 161,689) BSN will be:

$$0.888\text{Billion} = 52.26\% \times [161{,}689] \times \$10{,}514$$

Instead of using 1.7 Billion for creating 161,689 BSNs via online programs, the DM now could spend only 0.888 billion for adding 84,492 BSNs, resulting in a saving of 0.812Billion= [$1.7 Billion − $0.888Billion]. This savings of 0.812 Billion can be used to supplement the conversion cost to reduce the AD-D workforce IF it is needed. Let us now consider the scenario context variations. This is the final aspect of the What-If context.

The Best-Average/Usual-Worst Case Scenarios: Focusing the What-If Scenarios

According to Christenson (2006), experience teaches that What-If analyses can lack focus and this lack of focus creates volumes of output that overwhelms the DM and results in limited use of What-If analyses. One way to assure that this valuable idea of What-If modeling through the DSS does not fall into disuse due to information overload, is to create ONLY three DSS What-If versions and, of course, their respective SWAP benchmarks. Using a simple illustrative example, we wish to indicate how this Best-Average-Worse [BAW] Model generates important Range information and how this Range can be used by the DM in a focused way.

BAW Terminology. The term “Best Case” means whatever creates the relative lowest expenditure. For example, the Best Case in the Dynamic Change: DSS could be zero growth in the AD-DRN workforce and 10% growth in the BSN RN workforce. Or, when it comes to tuition expenditures, they will only grow by 0.5%, or, perhaps, expenditures for some program types may even fall. The “Worst Case” scenario has the opposite meaning;

expenditures will be relatively the largest. For example, the Worst Case could occur if there were no policies that were in effect to decrease the size of the AD-DRN work force and, instead, the AD-D workforce is expected to match the growth rate of the BSN group at 5% over the planning horizon. Additionally, due to the onerous implications of the Fiscal Cliff as it may impact the nursing work force subventions, expenditures for tuition are expected to grow by 5% annually over the planning horizon. The "Average/ Usual "Case is NOT the average of the two; it is what the DM feels is between the two extremes of the Worst Case and the Best Case or what is usually expected to happen. For example, the AD-D RN workforce grows modestly over the planning horizon, at an average rate of 2% annually and tuition expenditures grow at 1.25%. The values generated by the three BAW scenarios will be used by the DM in three What-If analyses to calculate their related expenditures. To illustrate, let us take other pilot test values for the Dynamic Change: DSS and the SWAP benchmark and also modify the nature of the cost configuration allocations to form the BAW information. This information is presented in the following table:

Table 2: Best Case, Average Case, and Worst Case Benchmarked Expenditures [in millions]

Dynamic Change[DC]	Dynamic Change Expenditure	SWAP EBM Benchmark
Worst Case	$46.5	12.7
Average/Usual Case	$12.9	3.1
Best Case	$1.7	1.07

Here, the DM can clearly observe the range of possibilities. The range of expenditures under all the possible cases that have been parameterized by the DM is [$1.7 to $46.5] million, with an average/usual value of $12.9 million. We recommend using this range as a way to better access the economic reality as projected by the DM. For example, if the Worst Case—i.e., an expenditure of $46.5 million over the planning horizon—is not likely to create funding issues, then this argues strongly for moving forward with the advanced planning to add the required numbers of BSN so as to realize the 80/20 Policy Initiative. The other situation, of course, is that perhaps the Best Case—i.e., an expenditure $1.7 million—is not possible to fund. In this case, there needs to be consideration given to re-designing the specifications of the project using the EBM prompt idea discussed above; this means not more What-If analyses but a re-definition of the goals of the project—e.g., a less ambitious blending where the goal falls within the politically feasible Expenditure Range. Of course, this is the exact reason that the What-if-Analysis is inextricably linked to the BAW analysis; in our experience, going back to the policy drawing board and re-designing the project goals often happens. The final extension of the What-If analysis is to use the three What-If scenarios and collapse them down to one value. We recommend in this regard the simple and most useful Expectation Model.

Expectation Model Synthesis: The Final Profiling Statistic

A final important decision making input that is recommended is to collapse BAW Range of possible expenditures to a single number. The usual and recommended way to do this is to use the concept of expectation [Rancan (2013)]. In this modeling context the DM indicates the percentage of time or expectation for each of the states: The Worst Case, The Average/Usual Case and the Best Case. This means that the DM will form the convex combination of these three performance statistics to get an overall expectation; this is another way of saying that given all the myriad numbers of dynamic effects considered by the DM—e.g., the circumstances of the global economy and in particular the Fiscal Cliff that is likely to affect the US Health Care Delivery System [HCDS] for decades to come [Postal & Festa (2013) and Bush (2012)]the DM estimates that the Worst Case could happen 27% of the time and that the Best Case could be the eventuality 38% of the time and so the Average Case will likely happen 35% of the time: [1-[27% + 38%]]. Applying these percentages to the BAW Range information in Table 2 we find the expectation to be:

Eq17 $E[BAW] = \$17.7{:}\ [\$46.5\ x\ .27] + [\$12.9\ x\ .35] + [\$1.7\ x\ .38]$

In similar fashion, the expectation of the Swap Ratio Benchmark will be: 4.9. The critical meaning of this expectation information is that the expectation of the BAW is a practical reality of the expenditure, as weighted by the DM. The Expectation is just as its label indicates—what the DM can expect given myriad dynamic effects. The Expectation can also be sees as what is the "best-bet" as to the actual expenditures in a dynamic and complicated world.

Conclusions

We have examined the technical inner workings of the two DSS, The Dynamic Change: DSS and a focused benchmark, the SWAP: DSS that were developed to assist heath planners in evaluating scenario alternatives regarding the ambitious project: The Robert Wood Johnson Foundation: Grant: [RWJ: 4466(2011)]in support of the Institute of Medicine's [IOM] Committee on The Future of Nursing recommendation: "Increase the relative proportion of nurses with a baccalaureate degree to 80% by 2020". Kovner, Lee, Lusk, Katigbak & Selander (2013).In addition, we demonstrated the What-If analysis concept and the EBM prompting useful in generating the various choice alternatives usually available to the DM in forming a policy package that is feasible and politically fundable. Finally, we noted that often the What-If concepts if not carefully focused can produce an overwhelming volume of information and the information overload negates the positives aspects of the What-If concept. In this regard we offered the Best, Average/Usual, and Worst Case as three What-If options. Further, these three BAW scenarios can be reduced to a single statistic using the Expectation Model.

The above information and the suggestions made to facilitate the utilization of these DSSs were here presented in detail so that the technical information will be transparently available in the case that other researchers will wish to modify these DSS. In this sense this is an important companion paper to the overview presented by Kovner, Lee, Lusk, Katigbak & Selander

(2013). Simply put BOTH presentations are needed to realize the benefits of these DSS.

As a note of caution, a massive amount of information may be generated by the DM using these DSSs. It will be tempting to prepare many DSS What-if-Analyses and reports including all the information generated; this is en vogue as Transparency. Transparency is, of course, a good thing; however, too much information is just as bad as insufficient disclosure. A compromise, which we like to call the "pine-tree- approach" is to adopt a reporting modality developed decades ago by many consulting organizations. In the pine-tree- approach, one starts with a carefully crafted Executive Summary of approximately 150 words. That is, words only! An Executive Brief should follow this. It should be four or five pages in length, built around the summary performance statistics, including numbers, figures, and/or tables. This executive brief usually includes a one-page Technical Appendix explaining technical details that add to understanding of the Executive Brief. The Executive Brief can be followed by a White Paper where all the same information in the Executive Summary and Executive Brief are presented with full details. For example, we have seen White Papers which were internal communications on consulting engagements of 200 to 300 pages where 75% of the White Paper was Appendices. Therein lays the name the pine-tree- approach; as one move down from the top of the pine tree, there are more and more branches extending out in all directions. We find the pine-tree-approach serves brevity without compromising transparency.

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