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Economic Evaluation of Enhancing Nurse Educational Level on In-Hospital Mortality: Cost per Prevented Death Analysis

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Abstract

Evaluation of the cost-effectiveness of increasing the employment share of nurses with higher education, analysed from the healthcare provider's perspective. Using findings from a 12-month investigation and data obtained from a large hospital, we estimated the costs associated with preventing a single death. The intervention consisted of a 10% rise in the proportion of nursing care hours delivered by nurses with higher education. Health outcomes were expressed as the cost of avoiding one death (CER). Cost-effectiveness analysis (CEA) served as the assessment approach. The additional expenditure related to employing a higher proportion of nurses with higher education totalled USD 11,730.62, representing a 3.02% increase compared with baseline costs. The projected number of deaths avoided was 44. Mortality per 1000 patient days was 9.42 before the intervention and 8.41 afterwards. The cost of preventing one death through a 10% increase in the share of BSN/MSN nursing care hours in non-surgical wards was USD 263.92. Expanding the proportion of care hours provided by nurses with tertiary education represents a cost-effective strategy for lowering in-hospital mortality.

Keywords: Cost-effectiveness analysis, Education level, Nurse staffing, In-hospital mortality

Introduction

In healthcare service management, increasing attention is devoted to optimising staffing levels within medical facilities. Budgetary constraints in healthcare and the wide range of potential resource allocation options create a need for economic evaluations that compare alternative scenarios in order to identify the most efficient interventions for achieving the best system outcomes, in this case, the prevention of patient death. Identifying optimal interventions requires the application of methods and tools appropriate for health technology assessment (HTA), in line with WHO recommendations—WHA67.23 [1, 2].

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The idea of avoidable mortality has developed since the 1970s, when a research group led by David D. Rutstein introduced a novel approach to assessing the quality of medical care by proposing the indicator of premature deaths from selected causes that could be avoided through appropriate treatment or prevented with adequate healthcare [3].

A search of the PubMed database was conducted for original research articles published between 1985 and 2021 using the terms: "cost-effectiveness", "nursing", "nurse staffing", and "in-hospital mortality". Numerous studies examined the relationship between increased nursing hours or higher levels of nursing education and in-hospital mortality; however, none included a cost-effectiveness analysis. Other studies assessed the cost-effectiveness of preventing specific adverse hospital events by modifying nurse staffing levels and/or education, but they did not address in-hospital mortality. No identified studies analysed the cost-effectiveness of interventions involving an increase in nursing hours per patient day (NHpPD) and/or a higher proportion of care hours delivered by nurses with higher education in relation to in-hospital mortality.

An expanding body of evidence indicates an association between nurse staffing, educational attainment, and in-hospital mortality [4–11]. One of the largest studies, carried out across nine European countries, provided robust evidence on the effects of nursing hours per patient per day (NHpPD) and nurses' educational level on adverse events, complications, and hospital mortality. These findings highlight the need for comparable, multidimensional analyses, particularly in countries not yet included in such research [12].

Conversely, some published studies have yielded inconclusive findings. Twigg's systematic review of investments aimed at improving nurse staffing did not demonstrate clear evidence of cost-effectiveness from a cost–benefit perspective in relation to patient safety [13, 14]. Therefore, further investigation and stronger evidence regarding the role of nurses' educational level remain necessary.

In 2018, Poland implemented a system of graduated nurse remuneration that is centred on educational attainment, with pay coefficients linked to education level [15–17]. As a result, new nurse employment standards came into force in Polish hospitals on 1 January 2019. In non-surgical wards, staffing requirements are set at 0.6 full-time equivalent positions per bed, while in surgical wards the requirement is 0.7. Nevertheless, there are no nationwide guidelines specifying optimal nurse-to-patient ratios or skill mix to support nursing managers in reducing the risk of adverse events.

In Poland, nursing education exists at two levels: nurses with higher education—those holding a bachelor's degree in nursing (European Qualifications Framework, EQF level 6, BSN) or a master's degree in nursing (EQF level 7, MSN)—and nurses with lower-level qualifications who graduated from nursing secondary schools (EQF level 4/5). These schools operated until 2002 [18].

Due to nurse shortages and one of the lowest nurse-to-population ratios in Europe, discussions have resumed in Poland regarding the reintroduction of vocational schools for certified nurses. Similar debates are occurring in other countries facing limited nursing workforces. This situation has intensified the need to evaluate both the clinical effectiveness and the cost-effectiveness of raising nurses' educational levels, particularly with respect to patient safety and the financial implications for providers, payers, and society. Over the past decade, overall in-hospital mortality in Poland declined slightly, from 2.3% in 2010 to 2.0% in 2018, which may reflect improvements in care quality [19]. At the same time, the proportion of nurses with higher education increased from 16% in 2013 to 30% in 2020 [20]. According to the Polish Accreditation Committee (Centre for Quality Monitoring in Health Care, CMJ), analysing in-hospital and avoidable mortality can be a useful approach for evaluating and enhancing healthcare quality.

The objective of this study is to evaluate the cost-effectiveness of employing a greater number of nurses with higher education from the service provider's perspective.

Materials and Methods

At present, Polish literature lacks analyses that jointly address the relationship between nurse staffing levels, adverse event occurrence, and the financial implications of such staffing investments. Nurse workforce characteristics in Poland were therefore examined using data derived from a three-year investigation conducted between January 2012 and December 2014 in a large, specialised hospital comprising 523 beds. The study adopted a retrospective case–control design and utilised archived patient medical documentation alongside nursing employment records. The analysis demonstrated that non-surgical wards with a higher share of nursing care hours delivered by BSN- and MSN-qualified nurses experienced fewer deaths. Specifically, an increase of 10 percentage points in the proportion of nursing care hours (NCH) provided by BSNs/MSNs (BSN/MSN NCH) was associated with a mortality reduction of 7.53 per 1000 patient-days [10].

Cost-effectiveness analysis (CEA) served as the primary methodological framework for evaluation. The economic modelling approach followed established CEA principles, consistent with the methodology applied in the NICE (National Institute for Health Excellence) report authored by Cookson [21].

Effectiveness inputs for the model were obtained from the Polish study conducted by Wieczorek–Wojcik, which characterised routine hospital care by the proportion of nurses with higher education working in non-surgical wards [10]. The year 2014 was selected as the reference year for the CEA, as the period from 2012 to 2014 was marked by a steady rise in the proportion of nursing hours per patient per day (NHPPD) delivered by nurses with higher education, increasing from 24.62 ± 16.78 to 39.16 ± 17.82.

The study cohort included adult patients admitted to four non-surgical hospital wards. Over the analysed timeframe, 6031 individuals were hospitalised, generating a total of 43,502 patient-days. The average patient age was 57.4 years. A total of 410 deaths occurring in non-surgical wards were included in the analysis. The baseline proportion of nursing hours provided by higher-educated nurses in these wards was 32.2%. The intervention scenario assumed a 10% increase in this proportion, raising it to 42.2%.

The intervention consisted of expanding nursing care hours (NCH) delivered by BSN-qualified nurses by 10%. The volume of additional BSN/MSN nursing hours was calculated by applying a 10% increase to the existing number of BSN/MSN NCH in each ward.

Intervention costs were estimated by determining the difference between the hourly cost of care delivered by nurses with higher education and the hourly cost of care delivered by nurses without higher education, and then multiplying this difference by the number of additional BSN/MSN NCH. The unit cost of one nursing hour was calculated by dividing total nursing remuneration by the actual number of NCH during the study period. The cost per hour of care provided by BSN/MSN nurses was computed by dividing their total salary expenditure by the corresponding BSN/MSN NCH, with analogous calculations performed for nurses without higher education.

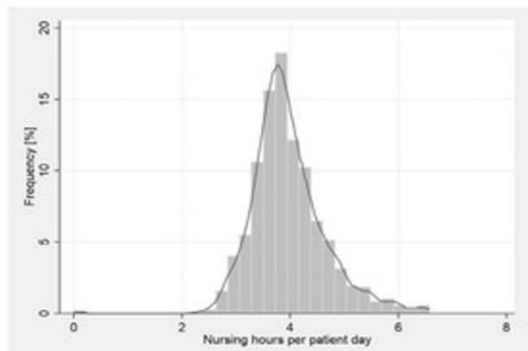
Mortality outcomes were assessed for the following non-surgical wards: general medicine, pulmonology, neurology, and cardiology. Mortality rates per 1000 patient-days were calculated for both the baseline and post-intervention scenarios, the latter reflecting a 10% increase in nursing hours provided by higher-educated nurses. The incremental difference in mortality between these scenarios was subsequently derived. The number of potentially preventable deaths resulting from the intervention was then estimated. Avoidable deaths in each ward were calculated by dividing the additional nursing hours delivered by higher-educated nurses by 7.53 per 1000 patient-days.

The cost-effectiveness ratio (CER) was employed as the principal outcome indicator to quantify the economic efficiency of the intervention and to estimate the cost associated with preventing one death. CER represents the cost per unit of health effect and constitutes the fundamental metric for comparing alternative strategies. This value was benchmarked against the revenue generated by the healthcare provider per patient.

Ethical approval for the study was obtained from the Bioethics Committee of the Medical University of Gdansk.

Results and Discussion

The distribution of nursing hours per patient per day (NHPpD) in non-surgical wards illustrates the observed ranges and frequencies of nursing care provision across the four analysed wards, as depicted in **Figure 1**.



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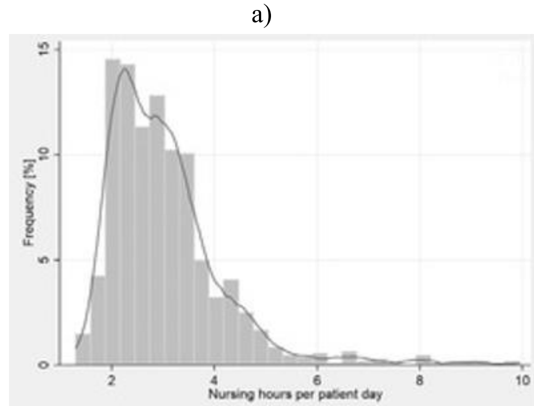

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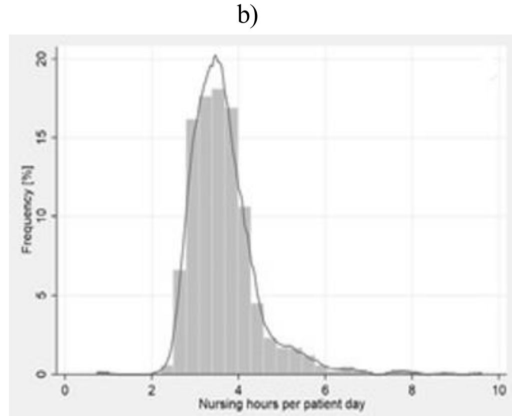

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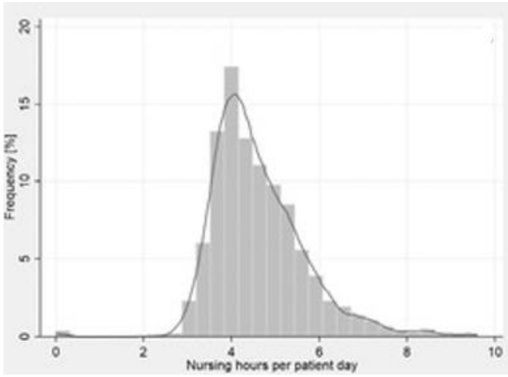

d)

Figure 1. Distribution histograms and fitted models of the nursing care index (NHPpD) in non-surgical wards: (a) general ward, (b) pulmonology, (c) cardiology, (d) neurology.

Across all non-surgical wards, nurses with higher education accounted for an average of 32.2% of total nursing care hours. The neurology ward exhibited the highest proportion (46.3%), whereas the pulmonology ward recorded the lowest value (19.2%), as shown in **Table 1.**

Table 1. Descriptive statistical measures for the proportion of nurses with university-level education during the entire observation period, stratified by non-surgical ward.

Wards	Q_1	Q_3	SD	M	Me	Min	Max
General Ward	30.0%	45.5%	12.5%	38.4%	36.4%	0.0%	83.3%
Pulmonology	12.5%	28.6%	14.6%	19.2%	16.7%	0.0%	75.0%
Cardiology	12.5%	33.3%	12.3%	24.2%	25.0%	0.0%	60.0%
Neurology	37.5%	55.6%	14.7%	46.8%	45.5%	0.0%	90.9%
Non-surgical wards	20.0%	44.4%	17.5%	32.2%	33.3%	0.0%	90.9%

Legend: min—minimum; max—maximum; M—mean; SD—standard deviation; Q1—first quartile; Q3—third quartile.

Backward stepwise regression analysis (β (SE)/100) confirmed a statistically significant association between nurses' educational attainment (HE—higher education) and in-hospital mortality frequency (–0.7529 (0.1385) USD). Only variables with p-values below 0.001 were considered statistically significant. The results indicate that an appropriate skill-mix modification would involve increasing the proportion of registered nurses by 10 percentage points, from the ward-level mean of 32.2% to 42.2%.

The cumulative number of nursing care hours in non-surgical wards amounted to 177,723. Within the analysed wards, implementing a 10% increase in BSN/MSN NCH translated into an additional 5905.2 hours of nursing care **(Table 2).**

Table 2. Nursing care hours (NHC) before and after implementation of the intervention.

Ward	Nursing Care Hours Provided by Nurses with Higher Education (BSN/MSN)	Additional Hours from 10% Increase in Higher-Education Nursing Care Hours	Total Nursing Care Hours
General ward	22,072	2,207.2	57,330
Neurology	19,675	1,967.6	42,042
Cardiology	11,099	1,109.9	45,864
Pulmonology	6,205	620.5	32,487
Non-surgical wards total	**59,051.8**	**5,905.2**	**177,723**

The intervention cost was estimated using empirical nursing care hours (NCH) data. In the examined non-surgical units, cumulative nurse wage expenditure reached USD 784,799.66, of which USD 381,370.21 was attributable to nurses holding BSN/MSN qualifications.

During the analysed year, the mean income generated per patient equalled USD 1096.10, whereas the corresponding mean treatment cost per patient was USD 1038.91 **(Table 3).**

Table 3. Patient-level revenue and cost structure in non-surgical wards.

Ward	Gross Salary of Nurses with Higher Education (BSN/MSN) (USD)	Total Gross Salary of Nurses (USD)	Number of Patients (Annual)	Number of Patient Days	Average Revenue per Patient (USD)	Average Cost per Patient (USD)	Total Costs (USD)
General Ward	171,831.47	262,736.84	2,073.00	16,835.00	1,172.49	951.29	1,972,564.39
Pulmonology	41,183.65	116,934.49	1,129.00	7,201.00	948.23	818.59	924,412.09
Neurology	97,696.53	198,297.31	1,028.00	8,797.00	1,485.56	1,450.17	1,493,281.08
Cardiology	70,658.57	206,831.02	1,801.00	10,669.00	878.57	935.61	1,687,290.03
Non-surgical wards total	**381,370.21**	**784,799.66**	**6,031.00**	**43,502.00**	**1,096.10**	**1,038.91**	**6,077,547.59**

Across non-surgical wards, the mean expenditure for one hour of nursing care was USD 4.45. In contrast, one hour of care delivered by BSN/MSN-qualified nurses averaged USD 6.56. Expanding the share of BSN/MSN nurses led to an incremental expense of USD 11,730.62, corresponding to a 3.02% increase relative to baseline remuneration costs, defined as salaries paid to nurses without higher education. This figure was obtained by deducting the wage cost of nurses without higher education from the expenditure required to employ an additional 10% proportion of BSN/MSN nurses. The per-patient cost of increasing higher-educated nursing hours by 10% was USD 1.95. For the payer to cover this intervention, per-patient revenue in non-surgical wards would need to rise by 0.2%.

Implementing a 10% increase in BSN/MSN nursing care hours in non-surgical wards was estimated to prevent 44 deaths. Before the one-year intervention period, total mortality numbered 410 deaths. Ward-specific mortality figures were as follows: general ward—267, pulmonology—34, neurology—60, cardiology—29. The projected distribution of avoidable deaths included 17 in the general ward, 5 in pulmonology, 15 in neurology, and 8 in cardiology.

Baseline mortality was 9.42 per 1000 patient-days and declined to 8.41 per 1000 patient-days following the intervention. This represents an incremental reduction of 1.01 deaths per 1000 patient-days in non-surgical wards.

Cost-effectiveness analyses

The cost-effectiveness ratio (CER) was determined by dividing the total intervention expenditure by the estimated number of deaths avoided. Under the scenario of a 10% increase in BSN/MSN nursing care hours in non-surgical wards, the calculated cost per death averted was USD 263.92 **(Table 4).**

Table 4. Per-patient intervention costs and cost-effectiveness ratio (CER) for avoided mortality.

Ward	Cost of 10% Increase in Proportion of Higher-Educated Nurses per Patient (USD)	Cost of 10% Increase in Proportion of Higher-Educated Nurses (USD)	Cost-Effectiveness Ratio (CER): Cost per Prevented Death (USD)	Estimated Number of Preventable Deaths
General Ward	12.22	7,225.54	435.87	17
Pulmonology	1.69	1,907.94	406.22	5
Neurology	0.48	498.41	33.64	15
Cardiology	1.17	2,098.74	251.12	8
Non-surgical wards total	**1.95**	**11,730.62**	**263.92**	**44**

Sensitivity analysis

To test the stability of the findings, a sensitivity analysis was conducted. This procedure applies boundary-case yet plausible assumptions to parameters influencing the primary outcome, namely the cost of preventing one death. Both optimistic and pessimistic scenarios were simulated to reflect potential future variability. The resulting estimates showed minimal divergence between extreme cases, suggesting a low probability that real-world outcomes would differ materially from those predicted by the economic model.

For the scenario involving a 10% increase in the proportion of nurses with higher education, the sensitivity analysis incorporated variability in patient-days and nursing care hour costs. The following parameters were adjusted:

- Volume of BSN/MSc nursing hours—standard deviation values were derived from quarterly ward-level intervention data; these were multiplied by four quarters and either subtracted from the baseline nursing hour volume (pessimistic case) or added to it (optimistic case).
- Unit cost of BSN/MSc nursing hours—the standard deviation was calculated using annual data from the medical treatment ward and added to the base hourly cost under the pessimistic assumption.
- Number of avoidable deaths—standard deviation estimates based on annual medical treatment ward data were added to the baseline mortality figure (pessimistic case) or subtracted from it (optimistic case).

A deterministic, multi-variable sensitivity analysis was subsequently performed, targeting parameters characterised by substantial uncertainty or variability within the evaluated setting **(Table 5).**

Table 5. Sensitivity analysis.

	CER—Avoidable Deaths Increasing the Percentage of Hours of Care Provided by Nurses with Higher Education by 10% in Non-Surgical Wards Variant		
Parameter	**Optimistic**	**Pessimistic**	**Standard**
Total nursing hours provided by BSN/MSc nurses (PLN)	820.01	1155.92	925.57
Total nursing hours provided by BSN/MSc nurses (USD)	233.82	329.60	263.92
Cost of one nursing hour – BSN/MSc (PLN)	925.57	1432.85	925.57
Cost of one nursing hour – BSN/MSc (USD)	263.92	408.57	263.92
Number of preventable deaths avoided (PLN)	829.97	1 046.07	925.57
Number of preventable deaths avoided (USD)	236.66	298.28	263.92

Within the sensitivity assessment, both favourable and unfavourable variants were modelled for the intervention involving a 10% rise in the proportion of BSN/MSN nursing care hours (NCH) in non-surgical wards. The objective was to determine the extent to which the intervention outcomes might diverge from those predicted by the economic model.

Under the optimistic assumptions applied to the sensitivity analysis of the 10% BSN/MSN NCH increase, a reduction in nursing hours to 4899.24 led to a decrease in the cost-effectiveness ratio (CER) to USD 233.82. Conversely, in the pessimistic variant, expanding nursing hours to 6906.16 resulted in an increase in CER to USD 329.60. This level of cost implies that, under current reimbursement conditions, the intervention would no longer be financially viable for the hospital (USD −65.7). When assuming a higher number of preventable deaths in the optimistic scenario—by increasing the base value by the standard deviation to 49.6—the CER declined to USD 236.66. In contrast, under pessimistic assumptions, where the number of avoidable deaths dropped to 39.3, the CER rose to USD 298.28. This outcome again indicates financial non-viability of the intervention for the hospital, given the existing payer reimbursement level (USD −34.36).

Based on the adopted assumptions, an increase in the hourly cost of care delivered by higher-educated nurses by one standard deviation resulted in a CER of USD 408.67. Such an increase renders the intervention unprofitable under current payer financing arrangements (USD −145). The optimistic variant did not include a reduction in the hourly cost of care; therefore, this parameter did not influence CER in that scenario.

To evaluate the cost-effectiveness of increasing higher-educated nursing hours from a societal viewpoint, a cost–benefit analysis (CBA) was conducted. This analysis estimated a total gross societal benefit of USD 14,790,547.93, reflecting the prevention of 44 deaths. In

2014, the World Bank estimated the value of a statistical life (VSL) in Poland at USD 332,765.9. The present analysis determined the expenditure required to save 1 PLN. Using the cost–benefit ratio (CBR), results were initially calculated in PLN and subsequently converted to USD. The findings indicate that each PLN saved through increasing nursing care hours delivered by higher-educated nurses corresponds to a cost of USD 0.0002 (PLN 0.0008). The benefit–cost ratio (BCR) amounted to USD 359.57 (PLN 1.261), meaning that every PLN invested yields USD 359.57 (PLN 1.261) in societal benefits. Changes in the cost of avoiding one death (CER) across the analysed scenarios are presented in **Table 5.**

This study represents the first Polish analysis examining the cost-effectiveness of increasing nurses' educational levels in relation to in-hospital mortality. For the intervention consisting of a 10% increase in BSN/MSN nursing care hours in non-surgical wards, the estimated cost of preventing one death (CER) was USD 263.92.

The cost-effectiveness evaluation conducted for this study began by defining the interventions under comparison and identifying the analytical perspective. The selected population comprised adult patients admitted to non-surgical wards, with 2014 serving as the reference year. The intervention involved a 10% increase in nursing hours provided by nurses with higher education relative to the comparator, which reflected the standard proportion of such hours (32.2%). This baseline value was derived from a previously completed case–control study. The assumed health outcome was a reduction in mortality. The economic analysis was conducted from the service provider's perspective.

Following this, intervention-related costs were calculated. The number of additional nursing hours delivered by higher-educated nurses was estimated and monetised. All calculations were performed using an Excel spreadsheet. Unit costs per nursing hour were established, including costs per hour of care delivered by nurses with higher education, and total intervention costs were derived. Nursing hour costs were based on data from the SGA Report for 2014 [22]. Mortality data from non-surgical wards in 2014 were included in the analysis. Intermediate outcomes, defined as observed deaths, were subsequently extrapolated to final outcomes, namely, avoidable deaths. The number of avoidable deaths was estimated using a ratio of 7.35 per 1000 patient-days, obtained from a prior case–control study [10]. Finally, the cost per effect unit—CER for avoidable death—was calculated.

The analysis indicates that decisions regarding acceptance or rejection of the intervention depend on the service provider's own threshold for an acceptable CER, which may necessitate supplementary information. At the same time, in 2013, eleven European Union member states, including Poland, were advised within the European Semester framework to reform their healthcare systems. These recommendations largely emphasised financial sustainability and cost control, particularly through reforms in hospital care and healthcare pricing mechanisms [23].

Although the costs associated with a 10% increase in nursing hours delivered by higher-educated nurses were substantial, the intervention proved highly effective when compared with the standard care scenario. The per-patient cost of USD 1.95 is considered acceptable by the authors, especially in the context of Poland's historically low nursing workforce levels. In 2020, Poland reported only 6 nurses per 1000 inhabitants [24].

The authors argue that persistent workforce shortages will compel healthcare administrators to absorb additional costs. In healthcare systems, market prices do not always correspond to the true value of resources, including nursing labour. Changes in nurse remuneration may result from professional advocacy rather than market valuation of qualifications. Ongoing staff shortages, combined with frequent industrial actions linked to wage demands, may force hospitals to maintain operational continuity by raising salaries beyond levels justified purely by cost-effectiveness considerations.

Within the sensitivity assessment, the cost-effectiveness ratio (CER) indicators were recalculated after modifying selected estimated input parameters. The objective of this procedure was to evaluate the robustness and trustworthiness of the obtained results. All computations were performed using an Excel spreadsheet. Two alternative assumptions reflecting data variability were applied: an optimistic scenario and a pessimistic scenario. The sensitivity model incorporated values for variables influencing the final outcome, namely the number of nursing care hours delivered by nurses with higher education, the unit cost of one hour of nursing care provided by such nurses, and the number of deaths considered avoidable. The analysis conducted for this publication demonstrates that fluctuations in the hourly cost of higher-educated nursing staff have a stronger impact on overall costs than changes in the number of hours worked. Across scenarios reflecting parameter uncertainty, the intervention generates expenditures that, according to the authors, may remain acceptable for the service provider. Consequently, the findings support a recommendation to continue employing nurses with higher education in non-surgical wards.

Comparable research conducted in the United Kingdom estimated that preventing deaths through an increase of one hour in average nursing hours per patient per day (NHPPD) corresponded to an 8% reduction in mortality risk. That study reported that adding one NHPPD hour yields increasing benefits but also higher expenditures. Annual intervention costs were estimated at GBP 10.1 million, with a gross cost per patient of GBP 219 and a cost per life saved of GBP 69.097. A staffing increase, reducing mortality risk by 2% was associated with an expense of GBP 70 per patient. Under assumptions of enhanced staff structure, the value of one saved life was estimated at GBP 7.015, while under pessimistic assumptions it reached GBP 21.013. Overall, increasing staffing levels generated an estimated annual gross cost of GBP 1.3 million (0.3% of the budget), GBP 26.351 per life saved, and GBP 28 per patient [25].

Findings reported by Shamliyan indicate that the highest economic return from improved nurse staffing occurs when full-time equivalent (FTE) positions for higher-educated nurses increase by 0.56–1.5 per patient-day; however, hospital remuneration costs exceed the resulting benefits [9]. Rothberg reported that decreasing the patient-to-nurse ratio from 8 to 7 yields a cost of USD 56.394 per life saved, whereas reducing it from 5 to 4 patients increases this cost to USD 174.464 [26]. Behner *et al*. demonstrated that a 20% reduction in nurse employment led to complication-related costs that were USD 28.441 higher than the savings achieved through staff reductions [27]. Research by Weiss *et al*. showed that although the payer saves USD 652 per hospitalisation, hospitals incur a loss of USD 213 per patient when BSN/MSN care hours increase by one standard deviation (0.75 NHpPD). In that study, the intervention cost per patient was USD 198, while payer savings amounted to USD 607 per patient [28].

Evaluations of the clinical effectiveness and economic impact of highly qualified nurses, including nurse practitioners, on outcomes in both surgical and non-surgical wards demonstrate an association with lower in-hospital mortality, albeit accompanied by increased costs. Improvements in nursing care in non-surgical wards are particularly critical, as evidence suggests that mortality risk in these wards is over 50% higher and the likelihood of avoidable death is lower than in surgical wards [29].

The present findings indicate that although higher education influences nursing hour costs in Poland, its effect is modest compared with the influence of professional experience. At the same time, a strong association exists between the proportion of BSN/MSN nurses and reductions in ward-level mortality, pointing to greater effectiveness of higher-educated nursing staff. These results support the validity of the nursing education and training reforms introduced in Poland during the 1990s. As a consequence, the proportion of BSN/MSN nurses has continued to rise [20]. It can therefore be expected that nursing care effectiveness will further improve. Nonetheless, ongoing monitoring of the relationship between BSN/MSN workforce expansion and mortality outcomes remains necessary, justifying continued research in this field.

Polish hospitals face substantial debt burdens and operate under challenging financial conditions. At the same time, one of the core components of the Triple Aim framework developed by the Institute for Healthcare Improvement (IHI) is cost containment [30]. As a result, healthcare managers seek to limit treatment expenditures. The European Commission has also highlighted the importance of appropriate health service costing [31]. Thomas *et al*. described three forms of system resilience: financial, adaptive, and transformational [32, 33]. Currently, Poland's healthcare financing system does not link reimbursement to outcomes in accordance with value-based healthcare (VBHC) principles. Adoption of such a system would allow funding to reflect nursing effectiveness in terms of clinical outcomes, including in-hospital mortality. While this approach has often been considered advantageous primarily at the societal or system level rather than for individual hospitals, the present study demonstrates that it may also improve hospital financial performance. These conclusions are supported by recent findings from Griffiths *et al*., who showed that flexible and resilient nurse staffing strategies contribute to cost-effective hospital care while addressing workforce shortages [34].

When considering potential payer benefits, adopting a broader social perspective, as applied in hospital-based health technology assessment (HB-HTA), is warranted. Such an approach suggests that investing in nurse education may be more advantageous than merely increasing NHpPD. The intervention involving a 10% rise in BSN/MSN nursing care hours in non-surgical wards results in the avoidance of 1.01 deaths per 1000 patient-days. This intervention is characterised by a relatively low CER, making its implementation beneficial for hospitals.

To date, assessments of nurse staffing effectiveness have largely relied on cost-effectiveness analysis (CEA) and cost-utility analysis (CUA) from the provider perspective, without incorporating broader social considerations [35–37]. The World Health Organization recommends Hospital-Based Health Technology Assessment (HB-HTA) as an appropriate methodology for estimating the costs of preventing adverse treatment outcomes, including mortality [1]. HB-HTA enhances decision-making capacity at the hospital level and, indirectly, at the national and European levels [13, 14].

In nursing practice, performing case–cost evaluations is challenging because cost-related data are often unavailable, and obtaining them requires substantial effort and time. Moreover, Poland lacks centralised databases that would allow for large-scale statistical analyses of health events and their associated costs. The existence of such systems would make it possible to conduct economic evaluations on a broader scale. Although access to clinical information has improved due to the widespread use of hospital information systems (HIS), limitations remain. Clinical datasets are frequently incomplete or of insufficient quality, which complicates research activities. Economic evaluations require precise identification of employment-related nursing costs as well as the social benefits generated by implemented interventions. This is essential for evidence-based health policy aimed at strengthening health system resilience. Accordingly, EU Member States are encouraged to invest in improving data exchange mechanisms, such as ensuring the appropriate flow of patient-level information between healthcare providers and supporting more efficient and sustainable health system restructuring. The eHealth Task Force report entitled *"Redesigning Health in Europe for 2020"* emphasises the need for policymakers to fully leverage data resources [38].

The pandemic demonstrated that shifts in patient morbidity patterns can substantially influence the effectiveness of nursing interventions, particularly with respect to preventing avoidable deaths.

Another key issue highlighted by the authors concerns evaluating the economic benefits of reducing hospital mortality from a societal perspective, using estimates developed by World Bank experts [39], an area that remains underexplored.

In recent years, Poland has experienced a rapid increase in interest in applying economic evaluation methods to support rational decision-making in healthcare resource allocation and to enhance transparency in public expenditure. The Agency for Health Technology Assessment and Tariffs (AOTMiT) is responsible for assessing medical interventions, including those related to nursing practice [40]. Economic evaluation represents the most significant practical contribution of economics to healthcare decision-making processes [41]. This approach was endorsed by the European Commission in 2014, which identified Health Technology Assessment (HTA) as the primary tool for ensuring consistent evaluation of intervention effectiveness and accurate service costing, thereby enabling more efficient resource allocation. Accurate calculation of healthcare service costs is essential not only for expenditure control but also for informed investment and priority-setting decisions [23].

The additional expenditures associated with reducing mortality should be financed through an increase in health insurance contributions relative to GDP. In Poland, the health insurance contribution remains comparatively low at 9% [42]. Regulatory discussions are ongoing, as gradual increases—aligned with practices in other countries—are widely regarded as necessary. Improved care standards could also be achieved through supplementary insurance schemes, which are currently unavailable in Poland. At present, Polish hospitals are introducing standardised cost accounting systems as part of hospital-based health technology assessment (HB-HTA) initiatives led by AOTMiT. These systems will enable closer monitoring of human resource utilisation and potentially of care effectiveness. Over time, this may generate savings that could be redirected toward employing additional qualified nurses, as demonstrated in multiple studies [12] and confirmed by the authors' own research [10]. In Poland, hospital reimbursement is based on diagnosis-related group coding using the ICD-10 classification. However, no system exists for the independent accounting of nursing services. The introduction of a nursing-specific classification system, such as the International Classification for Nursing

Practice (ICNP), would allow for accurate costing of nursing services. Ultimately, this would enable separate reimbursement for nursing care and support the financing of nurses with higher qualifications, including higher education, within hospitals.
Consistent with the methodological approach applied in analyses of avoidable mortality conducted in high-income countries after 2000, the maximum age threshold was set at 75 years [43, 44]. In the present study, the average age of patients was 57.4 years.
The outcome measure adopted in this study was death. While mortality among older adults (above 70 years of age) is relatively common, deaths occurring in middle adulthood (30–69 years) are less expected [45]. Global estimates indicate that in 2010, approximately 57% of all deaths worldwide were classified as avoidable. Furthermore, over 27% of deaths attributed to chronic conditions occurred in individuals younger than 60 years and were considered preventable [46]. In 2012, chronic non-communicable diseases accounted for 68% of all global deaths (38 million out of 56 million). According to World Health Organization data, these diseases were responsible for 90% of all deaths in Poland in 2014 [47].
It should be clarified that, in the Polish context, references to nursing staff without higher education pertain to nurses who completed medical secondary school education. These schools ceased admitting new students in 1991, meaning that the last graduates will remain professionally active for at least another 9 years before reaching retirement age. At that time, the educational system allowed individuals to qualify as nurses without passing the final secondary school examination, which is currently required for university admission. In 2005, dedicated “bridging” programmes were introduced to enable these nurses to upgrade their qualifications and obtain a bachelor’s degree [48]. Nearly 50,000 nurses completed such programmes. Initially, participation required payment of tuition fees; however, between 2008 and 2015, the programmes were financed through an EU-funded initiative and offered free of charge [49].
Some nurses were unable to participate in the bridging programmes because they had not completed the final secondary school examination. Since 2005, nursing education in Poland has been delivered exclusively within the higher education system at accredited universities. Due to ongoing shortages in the nursing workforce, policymakers have renewed discussions regarding the potential reintroduction of nursing education at the secondary school level [50].
Research evidence demonstrates that increasing nurse staffing levels and/or raising educational requirements improves patient outcomes, although such improvements entail additional costs [10, 12]. Determining whether these costs are acceptable lies with the payer. While such investments may not be financially advantageous from an individual hospital’s perspective, they may be justified at the societal level, as enhancing nurse qualifications may prove more cost-effective than increasing NHPPD alone.

Conclusion

A cost-effectiveness analysis conducted across four non-surgical wards demonstrated that raising the proportion of nurses with higher education represents a cost-effective strategy for reducing in-hospital mortality. Allocating resources toward nursing care yields social benefits and may also offer financial advantages for the payer. Employing nurses with tertiary education constitutes a sound investment that contributes to lowering avoidable mortality. The implementation of an appropriate skill mix and structured competency frameworks within hospitals is therefore recommended. The findings presented in this study warrant further investigation using a multicentre design and the HB-HTA methodology, as the calculated CEA value suggests that healthcare providers require additional evidence to support decisions regarding intervention adoption or rejection. Establishing a defined CER threshold for determining cost-effectiveness would facilitate more consistent implementation decisions.

Limitations

This analysis is based on patient data obtained from a single healthcare institution. To ensure broader validity and reliability, future research should include larger patient populations and multiple medical facilities. Additionally, the evaluation adopts the employer’s perspective—specifically that of the hospital—when analysing costs and benefits.
The study does not account for social costs borne by the payer, such as expenses related to nurse education, nor does it quantify societal benefits associated with preventing a single death. From the standpoint of an individual hospital, increasing staff numbers or expanding the share of care hours delivered by BSNs/MSNs is feasible. However, at the national level,

such actions may negatively affect other institutions due to workforce redistribution.

The sensitivity analysis assumed identical changes in hourly nursing costs for staff with and without higher education, as this was considered the most probable scenario. In practice, however, cost fluctuations are likely to affect only one of these groups.

The findings also reveal substantial variation between wards in the proportion of nurses holding university degrees. When an overall 10% increase is applied, the smallest gains occur in wards with the lowest baseline staffing levels. This uneven distribution represents a limitation and complicates the interpretation of the results.

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