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Association between Sandbox Hospital Implementation and Patient Satisfaction Score (PSQ-18) in Pahang, Malaysia: A Quasi-Experimental Study

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Abstract

Introduction: Hospital administration often faced a significant pressure to enhance the balance between innovation and performance. Existing research on health innovation has largely focus on urban healthcare context with limited to no attention towards the rural healthcare setting. **Objective:** The study aim to demonstrate association between Sandbox Hospital implementation and Patient Satisfaction Score in Pahang, Malaysia. **Methods:** This study adopts three-year, quasi-experimental design, with non-equivalent groups, involving two-matched public hospital in Pahang Malaysia, utilizing cross-sectional data collected at two time points: pre-test (2023) and post-test (2025). Participants were selected based on predefined inclusion and exclusion criteria. Data were analyzed using descriptive and inferential statistics. **Results & Discussion:** Total of 5563 patients participated, with 49.5% patients in control group and 50.5% in the experimental group. All parameter in experimental group increased from 1.7% to 4.2% with statistically significant (RR = 1.35, $p < 0.05$). An estimated on average 4% difference-in-differences had been observed post implementation. The finding reinforces the argument that organizational innovations may has the potential to produce measurable improvements in healthcare delivery outcomes. **Conclusion:** The implementation of the Sandbox Hospital model has the potential to positively enhance patient satisfaction scores.

Keywords: Sandbox Hospital; Digital health; Technology Implementation

1 Introduction

Patient satisfaction can be considered as major indicator in every hospital performance [1]. Poor performance is often attributed to failure to adequately address patients' needs may result in reduced patient satisfaction [2]. Innovation is widely believed to be a key driver of improved patient satisfaction through various forms of process optimisation [3]. However in practice, hospital administrator often faced a significant pressure to enhance the balance between innovation and patients' needs [2]. While multiple factors contribute to this concerned, the implementation of health technology solution has emerged as critical determinant for most hospital [4]. At present, the current understanding on hospital-based innovation adoption is limited, especially on the role of technology in addressing patient satisfaction [5]. In this regard, most research on healthcare innovation has largely focused on urban healthcare contexts, with limited to no attention given to rural healthcare settings [6]. The issue is not rurality itself, but whether evidence generated in urban hospitals can validly be applied to rural hospitals across the country [7]. This often create a miss-matched on how the technology can best be adopted while preserving the patient satisfaction in multiple hospital environment [3]. Addressing this concern is important not only for patients, but also for the credibility of hospital services.

A close examination in today practise shows adoption of health innovation is often facilitated through various strategies [3]. One most notable is the concept of Living Labs, which attracted considerable global attention [8]. Originating in Europe, this concept had been defined as open innovation ecosystems where stakeholders such as users, researchers, industry players and policy makers collaborate to test and refine technology solutions in real-life contexts [9]. Unlike traditional laboratory settings, Living Labs emphasised iterative development and contextual adaptability [8]. Parallel to these concepts, the notion of regulatory sandboxes emerged. Initially popularised in the financial sector, the concept has progressively been adapted and integrated into the healthcare industry [2].

In recent years, Sandbox Hospital model has been proposed to accommodate technological shifts in healthcare. Although the sandbox concept originated in the UK in 2015, the term "Sandbox Hospital" was first introduced in Malaysia in 2022 [6]. The initiative was officially launched by the Ministry of Health and the Ministry of Science, Technology and Innovation, aiming to accelerate the adoption of emerging technologies within the local healthcare sector in Malaysia. Since then, five hospitals across various states in Malaysia have been designated as sandbox sites, including Hospital Putrajaya, Hospital Tunku Azizah Kuala Lumpur, Hospital Bera, Hospital Rembau and National Cancer Institute. A Sandbox Hospital can be defined as a controlled environment specifically designed to facilitate the testing and validation of innovative medical products, services and technologies [6]. It is a transformative process that offers a wide range of medical interventions across all levels of stakeholders, including healthcare workers and patients [10].

Sandbox Hospital adoption policy is fundamentally different from standard hospital policy. While standard hospital policy generally requires rigid compliance before any technology can enter a hospital setting, Sandbox Hospital policy provides adaptation of more flexible and agile-based methods [8]. By allowing such flexibility in real-life

settings, stakeholders such as regulators and administrators gain empirical insight into technology adoption benefits while minimising unnecessary risk to overall patient well-being [9]. Such measure can benefit both hospital management and patients. For instance, a study found that Sandbox policies had improved the interoperability of electronic medical records, resulting in significantly enhanced continuity of care for over 1.5 million patients annually across countries like Singapore, Malaysia, Thailand and Vietnam [6]. Studies also suggest that Sandbox Hospital policy is closely tied to improvement in quality of patient care, patient safety and patient comfort [2]. Those policies explicitly prioritise delivering the highest quality of patient care while adhering to regulatory requirements prior to introduction of newer health technology [8]. While prior studies have established that health technologies improve patient satisfaction, there is a lack of empirical evidence examining how different implementation strategies influence these outcomes.

Debate continues about the best strategies in measuring the patient satisfaction at the hospital setting [11]. Patient Satisfaction Questionnaire (PSQ-18) is a standardised, widely-used survey instrument specifically designed to evaluate a patient's attitude and happiness with received care [12]. Other commonly used strategies, such as the SERVQUAL model, the Hospital Consumer Assessment of Healthcare Providers and Systems, and Patient-Reported Experience Measures, are widely adopted frameworks in hospital settings for assessing patient experience and perceived quality of care. In Malaysia, PSQ-18 is used as the standard tool for evaluating patient satisfaction in almost all hospitals and health institutions [13]. PSQ-18 had been replacing the previous SERVQUAL method as early as 2023. By measuring patient satisfaction in the hospital, an administrator can predict whether the implementation of new technology will positively or negatively impact long-term hospital performance [2]. PSQ-18 consist of strategically incorporates a mix of both positively-worded and negatively-worded items for bias minimization and reliability [12]. The survey consists of 18 items that are systematically group into seven distinct domains as General Satisfaction (GSAT), Technical Quality (TECH), Interpersonal Aspects (INTER), Communication (COMM), Financial Aspects (FINAN), Time Spent with Doctor (TIME) and Accessibility/Availability/Convenience (CONV). Each of these 18 questions are assessed using a 5-point Likert scale, ranging from "Strongly Disagree" (1) to "Strongly Agree" (5) [13]. Although patient satisfaction is widely recognised as an important indicator of hospital performance, there is limited evidence on whether the Sandbox Hospital model translates this approach into tangible improvements in patient satisfaction outcomes. There remains a critical gap in understanding how implementing such a policy model can directly impact the psychological satisfaction of the patient receiving care, and overall public health outcome in Malaysia.

Therefore, the purpose of this study was to assess the association between Sandbox Hospital implementation and Patient Satisfaction Score, as measured by the PSQ-18, in two matched public hospitals located in rural Pahang, Malaysia. We hypothesised that patient satisfaction in the Sandbox Hospital would has a positive association following three years of implementation relative to a standard hospital.

2 Methods

2.1 Study design

A pre- and post quasi-experimental study was conducted using non-equivalent control group to evaluate the impact of Sandbox Hospital model implementation on patient satisfaction using PSQ-18 tools in Pahang, Malaysia. Although a randomized clinical trial is the best ways to minimize bias while control for cofounding variables, a quasi-experimental design was selected to preclude ethical and logistical issues associated with randomizing patient to different models of care, and to enhance the external validity of the study [14].

2.2 Setting and sample

This study had been conducted across two comparable hospitals, Hospital A and Hospital B, which demonstrate similarity in key organisational profile as shown in Tables 1. In the technological aspect, both hospitals demonstrate comparable digital maturity, including integrated Hospital Information Systems, technological support, network infrastructure, and staff exposure to health information systems. Participants were grouped according to the hospital in which they were admitted and received treatment during the study period. The control group received standard care under existing hospital policy at Hospital A. Accordingly, patients in the control group were not exposed to any experimental intervention or changes in standard hospital policy. The control group consisted of patients admitted under a standard care policy that shared similar baseline characteristics (e.g., age, gender, and ethnicity) but did not experience the Sandbox policy implementation. In contrast, the experimental group received care under the Sandbox Hospital model policy at Hospital B.

Table 1 Study sites profile between control and experiment group

Study Sites	**Hospital A**	**Hospital B**
No. Beds	40	40
Level of Care	Non-Specialist	Non-Specialist
States/Region	Pahang	Pahang
Geographical Status	Rural	Rural
Bed Occupancy Rate(%)	46.3	46.7
Admission per Year	2,729	2,972
Assigned Implementation	Standard Policy	Sandbox Hospital policy

Note: The baseline data were taken in 2023.

Inclusion criteria were patient who: (1) age more than 18 years old, and (2) provide written informed consent to participate in the study. While exclusion criteria were patient who: (1) age more less than 18 years old such as children or infant, (2) refuse to participate in the study, (3) transfer case to or from other hospital, (4) critically ill prior to admission and (5) incomplete or missing data during preliminary assessment of

participant eligibility. The flow diagram illustrating participant selection and analysis is presented in Figure 1.

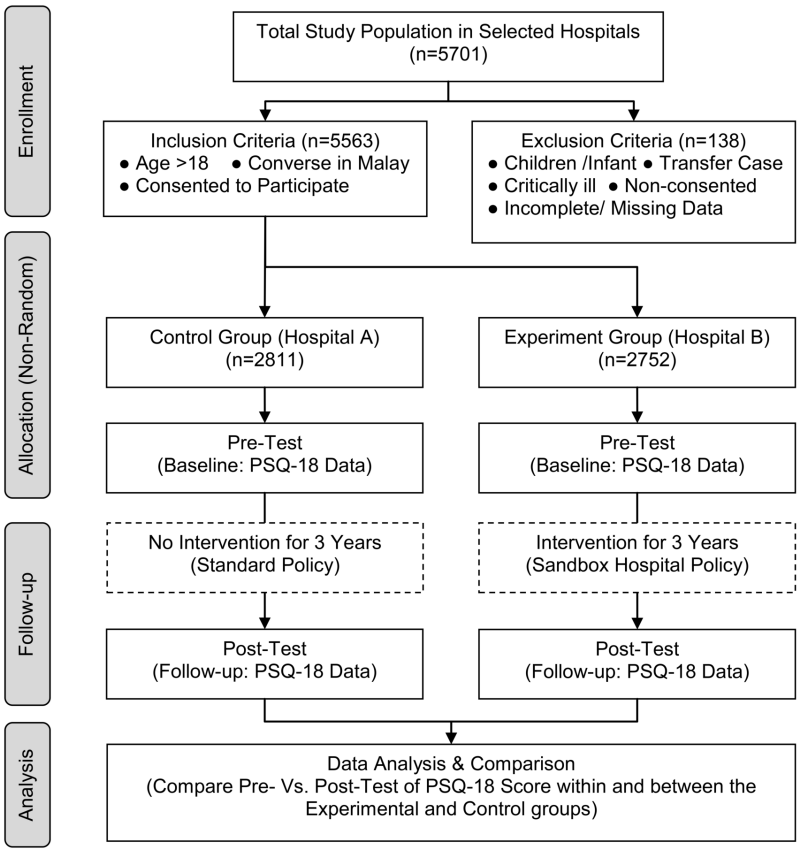


Fig. 1 Flow diagram showing total number of patients screened, exclusion numbers and reasons, and per group analysis.

2.3 Intervention

The Sandbox Hospital policy was implemented over a three-year period (2023–2025), and this study utilises existing PSQ-18 survey data collected by the hospital during the respective survey windows. The intervention was applied selectively at the policy level, focusing on a specific component of data integration between HIS modules to optimize clinical workflows. It is assumed that the Standard policy or Sandbox Hospital policy was implemented uniformly across all departments, with no significant variation in system functionality at respective hospitals [15].

2.4 Measures

Data were collected using a survey containing a PSQ-18 tool prior to the patient discharge. Demographic information included in this study was patients' age, gender, and ethnicity. As impact for hospital performance is not directly measurable, especially in the context of non revenue based public health institution, the study adopted validated patient satisfaction survey evaluation of PSQ-18 tools as proxy indicators. The PSQ-18 tools will be a self-reporting questionnaire rated on a Likert scale (e.g., 1 = "Strongly Disagree", 2 = "Disagree", 3 = "Neutral", 4 = "Agree", and 5 = "Strongly Agree"). Calculated mean scores will range from 1 to 5, with higher mean scores indicating greater patient satisfaction.

2.5 Data collection

The experimental group had been evaluated using survey conducted at two distinct time points: a pre-test utilizing the pre-implementation 2023 survey as baseline, and a post-test utilizing the post-implementation 2025 survey. Patient had been provided with informed consent and completes the pre-test 2023 survey consisting of PSQ-18 tools. To ensure compare comparability, the control group had been follow a data collection timeline that aligns with 2025 post test survey, or both the 2023 and 2025 survey depending on patient availability and conveniences. As policy outcomes cannot be adequately measured over a short duration, a three-year period (2023 to 2025) is considered sufficient for the duration of the study [16].

2.6 Data analysis

Collected data had been analysed using a statistical software package such as IBM SPSS. Descriptive statistics had been used to test whether the data were normally distributed. To test for homogeneity between experimental and control groups regarding demographic characteristics, independent t-test, chi-square test and Fisher's exact test had been utilised. To compare the post-test patient satisfaction results between the two groups, independent t-test had been used. To examine the effects of the Sandbox model implementation within the experimental group from 2023 pre-test to 2025 post test, Pearson Chi-square test had been applied. A strict one-tailed threshold of p-Value <0.05 is considered statistically significant for robust verification to reduced Type 1 error.

2.7 Ethical consideration

The study formally received ethical approval from the Medical Research and Ethics Committee, Ministry of Health Malaysia (NMRR ID-25-01213-E7C) on 5 June 2025 for the retrospective analysis of PSQ-18 data collected from 2023 onwards as part of routine hospital performance reporting. All procedures complied with institutional data governance and ethical requirements. A written approval from the respective participating hospitals via the hospital directors were obtained prior to the commencement of the study. The study had been conducted in accordance with the Code of Ethics (Declaration of Helsinki). In order to safeguards the patients' rights in research

participation and ensure hospitals anonymity, informed consent procedure was administered to all participants prior to the commencement of the study. No identifiable information were collected from either patients or hospitals being study.

3 Results

3.1 General characteristics and homogeneity of participants

A total of 5563 patients participated in the study, with almost equal (n= 2752, 49.5%) in the control group and (n= 2811, 50.5%) in the experimental group. In the control group, (n= 1267, 46.0%) patients completed the pre-test and (n= 1485, 54.0%) completed the post-test. In the experimental ground, (n= 790, 28.1%) patients completed the pre-test and (n= 2021, 71.9%) completed the post-test. The mean age of participants was 40.2 ± 14.4 years, and most patients were male (n=2899, 52.1%). Most patients were Bumiputera (n=3552, 63.9%) compared to non-Bumiputera (n=2011, 36.1%). General characteristics were found not statistically significant between the experimental and control groups. Thus, the homogeneity between the groups was confirmed as depicted in Table 2.

Table 2 Study sites profile between control and experiment group

Characteristic	**Total (n = 5563)**	**Con. (n = 2752)**	**Exp. (n = 2811)**	χ^2 **or** t	p**-Value**
Age (mean ± SD)	40.2 ± 14.4	39.9 ± 14.9	40.5 ± 13.8	-1.6	0.119
Gender (*N %*)				2.2	0.141
Male	1568 (55.8)	1481 (53.8)	1568 (55.8)		
Female	1243 (44.2)	1271 (46.2)	1243 (44.2)		
Ethnicity (*N %*)				0.3	0.565
Malay / Bumiputera	1661 (59.1)	1291 (46.9)	1661 (59.1)		
Chinese	814 (29.0)	510 (18.5)	814 (29.0)		
Indian	175 (6.2)	438 (15.9)	175 (6.2)		
Others	161 (5.7)	513 (18.6)	161 (5.7)		

Exp.= Experimental group, Con.= Control group, M= mean, SD= Standard Deviation, χ^2= Chi-Square, t= Paired t-test, p<0.05 statistically significant.

3.2 Between group differences and within group changes in patient satisfaction

As shown in Table 3, patient satisfaction across all measured PSQ-18 domains (GSAT, TECH, INTER, COMM, FINAN, TIME, and CONV) in the experimental group increased after the implementation of the Sandbox Hospital model. Conversely, the control group experienced relatively stable or declining satisfaction score across the same period. Among PSQ-18 domains, the INTER were noted to shown highest score while the CONV were noted to shown the lowest score in both groups.

The PSQ-18 was further converted into percentage (PSQ-18 x 20%) to determine the percentage different for each domain. As shown in Table 4, the experimental group

Table 3 Study sites profile between control and experiment groups

	Control group(M ± SD)		**Experiment group(M ± SD)**		
PSQ-18	**Pre.**	**Post.**	**Pre.**	**Post.**	**t(p-Value)**
GSAT	4.33 ± 0.23	4.36 ± 0.24	4.51 ± 0.46	4.64 ± 0.78	**5.383 (<0.05)**
TECH	4.21 ± 0.12	4.19 ± 0.72	4.30 ± 0.22	4.46 ± 0.52	**9.946 (<0.05)**
INTER	4.56 ± 0.41	4.41 ± 0.36	4.58 ± 0.42	4.66 ± 0.29	**6.038 (<0.05)**
COMM	4.52 ± 0.47	4.40 ± 0.21	4.51 ± 0.43	4.64 ± 0.46	**8.203 (<0.05)**
FINAN	4.40 ± 0.36	4.34 ± 0.24	4.38 ± 0.27	4.59 ± 0.61	**11.146 (<0.05)**
TIME	4.02 ± 0.22	4.07 ± 0.38	4.36 ± 0.51	4.50 ± 0.35	**8.713 (<0.05)**
CONV	4.01 ± 0.12	4.07 ± 0.52	4.14 ± 0.82	4.29 ± 0.13	**5.516 (<0.05)**

Pre.= Pre Test, Post.= Post Test, M= Mean, SD= Standard Deviation, t= Paired t-test, $p<0.05$ statistically significant.

showed an improvement in patient satisfaction scores from 1.7% to 4.2% between the pre-test and post-test. FINAN score reported highest increased (from 87.6% to 91.8%) while INTER score reported the lowest increased (91.5% to 93.2%) among experimental group. The control group showed various responses in patient satisfaction score form (-2.9% to 0.5%). While GSAT score slightly increased by 0.5% (from 86.6% to 87.1%) and TIME increased by 1.1% (from 80.3% to 81.4%), notable decreases occurred in the INTER domain (dropping 2.9% from 91.1% to 88.2%), the COMM domain (dropping 2.3% from 90.3% to 88.0%), and the FINAN domain (dropping 1.3% points from 88.0% to 86.7%).

A positive association was found between Sandbox Hospital implementation and Patient Satisfaction Score. Specifically, patients in the experimental group were 1.36 times more likely to report increased satisfaction in INTER, COMM, and FINAN domains. The experiment group also exhibited a 1.35 times higher likelihood of improved satisfaction in TECH domain. The experiment group shows 1.34 times more likely to improve satisfaction in CONV, GSAT and TIME domains compared to control group.

Average pre-test of control group (C0) was noted to be 85.9%, while experimental group (E0) was noted to be 87.9% respectively. After the implementation over three-years, average post-test of control group (Ci) was noted to be 85.2%, while experimental group (Ei) was noted to be 90.7% respectively. As shown in Figure 2, assuming there is a parallel line of experimental group, the difference-in-differences for PSQ-18 scores is -1% in the control group (Ci-C0) compared to 3% in the experimental group (Ei-E0). This resulted in an estimated 4% difference in changes following the implementation of the Sandbox Hospital over a three-year period.

Table 4 Study sites profile between control and experiment groups

	Con. (n=2752)			Exp. (n=2811)				
PSQ-18	**Pre. (n = 1267)**	**Post. (n = 1485)**	**%.diff.**	**Pre. (n = 790)**	**Post. (n = 2021)**	**%.diff.**	**RR**	χ^2(***p*-Value**)
GSAT	86.6	87.1	0.5	90.2	92.7	2.5	1.339	**180 (<0.05)**
TECH	84.2	83.7	-0.5	86.0	89.2	3.2	1.350	**183 (<0.05)**
INTER	91.1	88.2	-2.9	91.5	93.2	1.7	1.360	**193 (<0.05)**
COMM	90.3	88.0	-2.3	90.1	92.7	2.6	1.360	**193 (<0.05)**
FINAN	88.0	86.7	-1.3	87.6	91.8	4.2	1.359	**197 (<0.05)**
TIME	80.3	81.4	1.1	87.1	89.9	2.8	1.336	**170 (<0.05)**
CONV	81.1	81.4	0.3	82.8	85.7	2.9	1.343	**171 (<0.05)**

Exp.= experimental group, Con.= control group, Pre.= Pre Test, Post.= Post Test, diff.= Differences, RR= Relative Risk, χ^2= Chi-Squared, $p<0.05$ statistically significant.

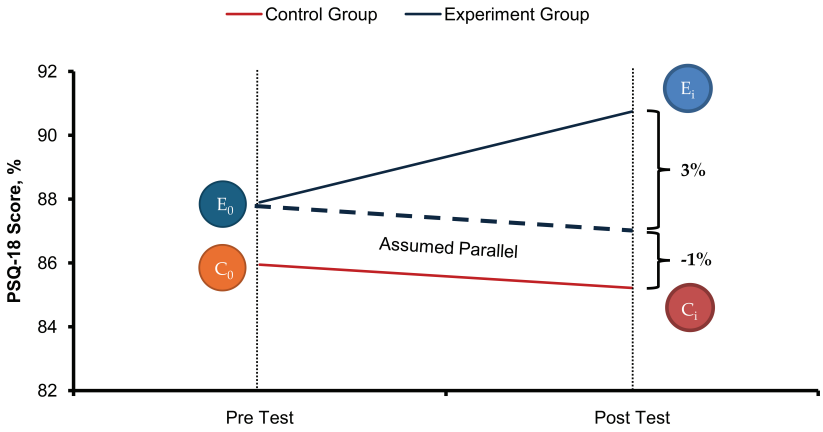


Fig. 2 Difference-in-Differences between Pre- and Post Test in Average PSQ-18 Scores.

4 Discussion

The study examines association between Patient Satisfaction Scores measured using PSQ-18 following three years of Sandbox Hospital implementation, involving two matched public hospitals in rural Pahang, Malaysia. Due to the inherent challenges of identifying an equivalent control hospital in a real-world healthcare setting, key confounding variables, including age, gender, and ethnicity, were standardised across the study groups to ensure baseline comparability of the study [17].

The study demonstrate that Interpersonal Aspects consistently recorded the highest scores in both groups. However, the magnitude of improvement was relatively small compared to other domains. In the control group, the score decreased from 91.1% to 88.2% (−2.9%), whereas in the intervention group, it increased from 91.5% to 93.2% (+1.7%), yielding a statistically significant difference between groups (RR = 1.36, $p < 0.05$). This pattern may be due to possible ceiling effect, where initially high baseline scores limited the potential for substantial improvement following the intervention [18]. This finding aligns with prior studies demonstrating the almost similar outcome [19]. This suggests a structured framework of a Sandbox Hospital may have the potential to optimize care delivery while maintaining high-quality patient–provider interactions even in the most high achiever domain.

The study revealed that Accessibility, Availability, and Convenience consistently recorded the lowest scores among all domains. In the control group, the score showed minimal change from 81.1% to 81.4% (+0.3%), whereas the intervention group demonstrated a more notable increase from 82.8% to 85.7% (+2.9%). The difference between groups was statistically significant (RR = 1.343, $p < 0.05$). This pattern suggests that in the most challenging domain, Sandbox Hospital adoption may gradually enhance patient experience even in areas initially perceived as weak performance as seen in other study [20].

The study found that the experimental group demonstrated significant increases in domains such as Technical Quality from 86.0% to 89.2% (+3.2%). The difference between groups was shown statistically significant (RR = 1.350, $p < 0.05$). Although here are conflicting findings in the other study, some study suggest that improved healthcare delivery may persist regardless of the level of technical quality [12]. This disparity emphasizes that while standard healthcare systems may struggle to maintain quality interactions, it is also dependent on growing clinical complexities [21]. The substantial improvements in these metrics suggest that patients were satisfied with the advanced knowledge of hospital staff in delivering optimal treatment, which was readily available and effectively applied in modernized care delivery.

Interestingly, Financial Aspects showed a shift from a slight decline in the control group (88.0% to 86.7%, -1.3%) to a notable improvement in the intervention group (87.6% to 91.8%, +4.2%), the highest improvement among the domains. The difference between groups was shown statistically significant (RR = 1.359, $p < 0.05$). A similar study in Cameroon supports this finding and found that cost-related factors can significantly influence patient satisfaction [12]. This finding suggests that enhanced perceptions of affordability or cost-related value may represent a principal determinant of patient satisfaction scores.

The study reveals that General Satisfaction increased modestly in the control group (86.6% to 87.1%, +0.5%) but improved more substantially in the intervention group (90.2% to 92.7%, +2.5%). The difference between groups was shown statistically significant (RR = 1.339, $p < 0.05$). A similar study in Oman found that the use of digitalization, such as telemedicine, could improve the overall satisfaction of patients [19]. This implies that General Satisfaction may constitute the most sensitive dimension influencing overall patient satisfaction scores.

One unanticipated finding was that, Communication initially declined in the control group (90.3% to 88.0%, -2.3%) but improved in the intervention group (90.1% to 92.7%, +2.6%). The difference between groups was shown statistically significant (RR = 1.339, $p < 0.05$). Several studies support this finding, which they found that effective communication is a key determinant for patient satisfaction [22]. This finding may be explained by interventions that potentially strengthened patient–provider interaction and improved the quality of information exchange [23]. This indicates that this domain might often poorly score in mass-outreach medical settings; however, the Sandbox model may appears to have some improved patient satisfaction score in this area.

The study found that Time-Related performance improved from 80.3% to 81.4% (+1.1%) in the control group and more substantially from 87.1% to 89.9% (+2.8%). The difference between groups was shown statistically significant (RR = 1.336, $p < 0.05$). This finding is consistent with previous studies demonstrating that digitalisation can minimise the time burden experienced by patients [24]. This finding suggests that the Sandbox Hospital model may benefit by improving operational efficiency and reduce perceived overall waiting times.

The study further demonstrated that the Sandbox Hospital policy model was associated with an approximately 4% increase in patient satisfaction scores. This finding is consistent with previous studies in Pahang Malaysia [3]. Although the magnitude

may appear small, such impact is often considered operationally significant in healthcare settings [3]. The finding suggest Sandbox Hospital model have the potential to significantly enhance overall hospital performance thought Patient Satisfaction Scores. The finding also reinforces the argument that organizational innovations may produce measurable improvements in healthcare delivery outcomes, as illustrated in 3.

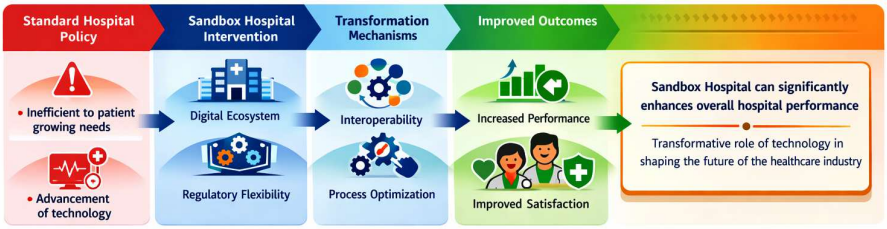


Fig. 3 Sandbox Hospital Implementation Model.

Together these studies provide an important insight into Sandbox Hospital overall adoption process [25]. At the core of Sandbox Hospital initiative are the National Technology and Innovation Sandbox of Health Technology Hub, which involves local regulators such as Malaysian Research Accelerator for Technology & Innovation (MRANTI) and Malaysian Health Technology Assessment Section (MAHTAS), plus other ministries and designated hospitals. The implementation process for Sandbox Hospital policy usually undergoes four distinct stages. In the first stage, developers submit proposals, coordinated by MRANTI and subsequently evaluated by MAHTAS, regarding potential clinical, economic and policy implications. In the second stage, MRANTI assesses local production and regulatory compliance. Innovators pitch to hospitals, and interested facilities submit documents of expression of interest and letters of intent. In the next stage, upon committee approval, testing begins with full cost transparency by the developers. A dedicated hospital team, alongside MRANTI and MAHTAS, oversees the trial to gather vital safety and operational data. In the final stage, the technology is removed post-trial, and a final report is submitted; this may occasionally trigger a formal procurement process if the hospital wishes to adopt the solution.

An implication of these finding suggest that Sandbox Hospital model not only promotes better patient satisfaction, but also has potential on the hospital revenue. According to Research2Guidance (2025), approximately 30–60% of hospitals in the United States and Europe are operating at negative financial margins, with comparable or more severe trends observed in Latin America, Africa, and parts of the Asia-Pacific region. Concurrently, the global digital health industry has expanded substantially, now encompassing more than 500,000 companies worldwide, thereby creating new economic opportunities for healthcare institutions [26]. Within this evolving landscape, Sandbox Hospital or other similar model such as living labs, clinical test-beds, or real-world testing environments, may demonstrate improved revenue models [6]. It is estimated that hospitals can access annual monetizable service opportunities exceeding approximately USD 1.1 billion per year 15. These include rental fees of approximately

USD 2,200 per day or royalty arrangements averaging 10% over a three-year period. These factors may contribute to improved hospital performance outcomes [27]. Furthermore, market analysis of the digital health industry projects an annual growth rate of more than 7%, which translates into a market volume in economy of US$258 billion per year by 2029 globally [28]. This study provides an exciting opportunity to advance our knowledge of Sandbox Hospital and its transformative role in shaping healthcare industry [29].

Several limitations need to be acknowledged. Firstly, the study utilized a quasi-experimental design rather than a randomized controlled trial. Although baseline characteristics between the control and experimental groups were statistically homogeneous, the lack of randomization means potential confounding variables could exist. Second, the study could not completely rule out the Hawthorne effect; hospital staff and patients in the experimental group may have altered their behavior or reported higher satisfaction simply because they knew they were participating in an intervention environment. Third, the study utilized the PSQ-18 as a self-reported evaluation instrument, which may introduce discrepancies between patients' subjective perceptions and objective assessments quality of care. Next, the study focused on public hospitals, which may limit the generalization of the findings far from private healthcare facilities. Finally, the study outcomes were measured shortly after the intervention, meaning the long-term sustainability of this heightened patient satisfaction remains uncertain. There are several areas for future research. For instant, more rigorous study designs are recommended to examine the long-term effects of Sandbox Hospital implementation using time-series analyses. In addition, comparative studies across different hospital types should be conducted to assess variations in hospital performance outcomes. Furthermore, randomized controlled trials are recommended to strengthen causal inference and minimize potential confounding factors.

5 Conclusion

In conclusion, the findings demonstrate that implementing the Sandbox Hospital can significantly enhances overall hospital performance, particularly in patient satisfaction. By employing quasi-experimental design with a non-equivalent control group over a three-year period, the data yield robust evidence that firmly confirmed the research hypothesis.

Supplementary Information

Additional Supporting Information may be found online in the supplementary information section for this article.

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review & editing. All authors: Validation, Writing- final approval of the manuscript, Project administration.

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Data availability. The datasets generated and/or analyzed during the current study are not publicly available due to confidentiality agreements with the participating institutions and the need to protect participant privacy. However, the data may be made available by the corresponding author upon reasonable request, subject to appropriate institutional approvals.

Declarations

Ethical statement. This research received ethical approval from Medical Research and Ethics Committee, Malaysia on 5th June 2025: NMRR ID-25-01213-E7C.

Consent for publication. Not applicable. The manuscript contains no identifiable individual data or images.

Competing interests. This study is a component of Iszaid doctoral thesis. The finding presented in this manuscript is part of a larger research project investigating Sandbox Hospital model. While this work may contribute to the thesis development, it is also presented as a stand-alone publication to disseminate its findings and insights to a broader audience. This manuscript has never been published in any other journal or duplicated in any way concerned. The authors declare no other conflict of interest.

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