Evaluating the impact of self-service cash deposit machines on the performance of commercial banks in Tanzania

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Abstract

This study aims to evaluate the impact of utilization of self-service cash deposit machines (SSCDMs) on the financial performance of Tanzanian commercial banks, focusing on key parameters like capital adequacy, asset quality, management quality, earning ability, and liquidity. The research, conducted over six years (2017–2022), utilizes a CAMEL analysis and combines secondary data review with primary data collected through interviews. Four commercial banks' audited financial statements serve as the primary data source. The findings indicate a mixed impact of SSCDM utilization on bank performance, with some banks experiencing positive effects on capital adequacy and liquidity ratios, while others show performance fluctuations. Overall, SSCDMs are found to enhance operational efficiency and convenience, attracting more customers and increasing deposit volumes. However, potential liquidity management challenges are noted. This study contributes valuable insights to the evolving Tanzanian banking sector, aiding policymakers and bank management in informed decision-making regarding self-service banking technologies**.**

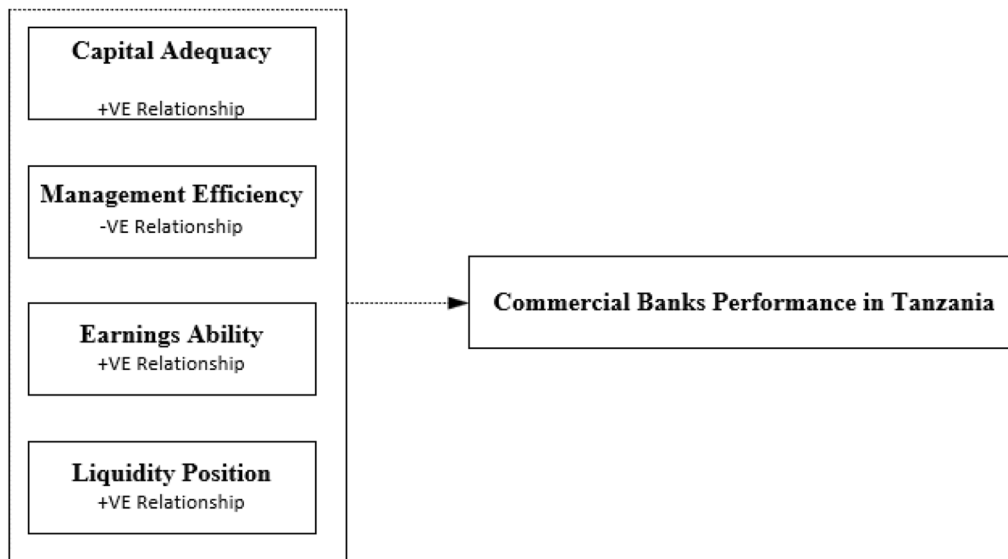**Keywords** Self-service cash deposit machines, CAMEL analysis, Performance

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Graphical abstract

Introduction

In recent years, the financial services industry has experienced a substantial transformation, primarily driven by technological advancements. One of the most noteworthy developments in this context is the widespread utilization of self-service technology, which empowers customers to conduct banking transactions independently and with unprecedented convenience. Among these self-service technologies, the introduction of self-service cash deposit machines (SSCDMs) has emerged as a significant milestone, offering financial institutions a powerful tool to augment operational efficiency, elevate the customer experience, and boost overall performance [21].

Within the financial services landscape of Tanzania, technological progress has been particularly notable in recent years, with self-service technology playing a pivotal role in reshaping traditional banking operations [9]. SSCDMs have risen to prominence within this technological wave, affording customers the ability to independently and conveniently deposit cash into their accounts [27]. The multifaceted advantages of this technology encompass cost reduction, heightened customer convenience, and enhanced operational efficiency, thereby making it a central focus for commercial banks operating in Tanzania [18].

The Tanzanian banking sector itself is characterized by a diverse mix of domestic and international financial institutions, with prominent players such as CRDB Bank and NMB. The regulatory framework governing this sector is overseen by the Bank of Tanzania (BOT), which has been actively promoting financial inclusion through initiatives such as mobile banking and microfinance. Notably, mobile money services, exemplified by Vodacom's M-Pesa, have gained widespread popularity, significantly improving access to financial services among the Tanzanian population. This progress has unfolded alongside broader technological advancements in the country, including initiatives to expand mobile and internet connectivity, the government's e-government programs aimed at enhancing service delivery, the burgeoning tech start-up ecosystem, and an increasing emphasis on cybersecurity. The exploration of blockchain technology and cryptocurrencies has also been a noteworthy development [9].

While self-service technology has demonstrated its potential in enhancing operational efficiency and customer satisfaction in various developed nations, its specific impact on the performance of commercial banks in Tanzania remains a relatively uncharted territory [9]. This knowledge gap underscores the importance of comprehending the precise effects of SSCDM utilization within the Tanzanian banking landscape, a critical endeavor for industry decision-makers [10]. Such understanding can shed light on areas for improvement and guide the formulation of strategies to harness the full spectrum of benefits that self-service technology utilization can offer.

Previous research has offered compelling evidence of the positive impact of self-service technology on various dimensions of the banking sector. For instance, a study by Pooya et al. [19] demonstrated that the utilization of self-service technology had a favorable influence on service quality, customer loyalty, and operational efficiency within the banking sector. Similarly, Ugwuanyi et al. [24] and Wei et al. [25, 26] reported that the utilization of self-service technology significantly enhanced the customer experience and the efficiency of service delivery in commercial banks.

Although commercial banks in Tanzania have widely utilized SSCDMs [17], there is a gap in understanding the actual influence of these machines on key performance indicators [23]. However, despite the widespread utilization of SSCDMs in Tanzanian commercial banks, there is a lack of comprehensive research examining their precise influence on critical performance indicators, such as capital adequacy, management efficiency, earnings, and liquidity position in commercial banks in Tanzania. The study aims to contribute to a comprehensive understanding of the impacts of SSCDMs in Tanzanian commercial banks, bridging the gap in existing research. The study tries to fulfil the following research objectives:

1. To evaluate the impact of SSCDMs on the capital adequacy of the commercial bank.
2. To assess the efficiency of the commercial bank's management in utilizing SSCDMs.
3. To analyze the impact of SSCDMs on the commercial bank's earnings.
4. To evaluate the effect of SSCDMs on the liquidity position of the commercial bank.

Theory and hypotheses development

The utilization of self-service cash deposit machines (SSCDMs) in the Tanzanian commercial banking sector has opened avenues for improved efficiency and customer service. This section outlines the theoretical framework and hypotheses development for investigating the impact of SSCDMs on key performance indicators, including capital adequacy, management efficiency, earnings, and liquidity position in commercial banks in Tanzania.

Impact on capital adequacy

The capital adequacy of a commercial bank is a critical factor in ensuring financial stability and compliance with regulatory requirements [3]. The utilization of SSCDMs may affect capital adequacy through increased operational efficiency, cost savings, and potential impacts on deposit levels.

H1   The utilization of SSCDMs positively impacts the capital adequacy of commercial banks in Tanzania.

Efficiency in management

Efficient management practices are vital for a bank's overall performance [11]. SSCDMs have the potential to streamline cash handling processes and reduce operational costs, thus influencing management efficiency.

H2   The utilization of SSCDMs leads to improved management efficiency in Tanzanian commercial banks.

Impact on earnings

Earnings are a fundamental aspect of a bank's financial performance [20]. SSCDMs may affect earnings through increased deposit volumes, reduced operating costs, and enhanced customer satisfaction.

H3   The utilization of SSCDMs positively impacts the earnings of commercial banks in Tanzania.

Effect on liquidity position

Liquidity is essential for a bank to meet its short-term obligations and respond to unexpected withdrawals [4]. SSCDMs can influence liquidity by affecting the inflow and outflow of cash within the bank.

H4   The utilization of SSCDMs has a significant effect on the liquidity position of commercial banks in Tanzania.

These hypotheses serve as the foundation for empirical testing and analysis to ascertain the extent to which SSCDM utilization influences the aforementioned key performance indicators in Tanzanian commercial banks. The study aims to provide a comprehensive understanding of the impact of SSCDMs in this context, thereby contributing to the existing body of knowledge in the field of banking.

Literature review

The adoption of SST in commercial banks has been driven by factors such as cost reduction, customer demand for convenience, and technological advancements [5, 7]. Automated teller machines (ATMs) and online banking platforms have gained popularity, offering cost savings and improved customer satisfaction [8, 13, 14].

SST has reduced the need for human interaction in routine transactions, resulting in cost savings for banks [5, 7]. It has also enhanced customer satisfaction by providing convenient and efficient services [13, 14] and

improved accessibility, particularly for underserved populations [15, 16].

However, challenges include the need for continuous technological upgrades, security concerns, and difficulties faced by some customers, particularly older individuals, in using SST due to limited technological literacy [6, 13–16]. Future trends in SST include the integration of advanced technologies like biometrics and artificial intelligence, as well as innovative applications such as personalized financial advice and virtual assistants [5, 7, 13, 14]. These trends are expected to further shape the landscape of SST in commercial banks.

The utilization of self-service cash deposit machines (SSCDMs) in the banking sector has significant implications for each of these key dimensions. This theoretical review explores the impact of SSCDMs on CAMEL analysis, focusing on how SSCDMs influence the various components of CAMEL.

Capital adequacy is a critical aspect of a bank's stability and ability to absorb losses. SSCDMs can indirectly influence capital adequacy by reducing operational costs, potentially leading to higher profits. A well-implemented SSCDM strategy can enhance capital adequacy by increasing a bank's profitability, allowing it to build and maintain a stronger capital base [5, 7].

Management quality encompasses various aspects of a bank's operations, including risk management, governance, and strategic decision-making. SSCDMs impact management quality by requiring efficient deployment and maintenance. Effective management of SSCDM networks is essential to ensure their security, functionality, and alignment with the bank's overall strategy [28].

Earnings reflect a bank's ability to generate profits from its operations. SSCDMs can influence earnings positively by reducing labor costs and increasing transaction volumes. A well-executed SSCDM strategy can enhance a bank's revenue stream, contributing to higher earnings. However, failures in SSCDM networks or inadequate customer education may lead to operational issues that impact earnings negatively [15, 16].

Liquidity measures a bank's ability to meet its short-term obligations. SSCDMs can impact liquidity positively by attracting deposits and providing customers with convenient cash deposit options. Increased liquidity can help banks better manage their short-term funding needs. However, banks must balance this with prudent liquidity management to prevent overreliance on SSCDM-generated deposits [22].

The introduction and effective utilization of SSCDMs in the banking sector have significant implications for CAMEL analysis. SSCDMs can positively influence capital adequacy, earnings, and liquidity when strategically integrated into a bank's operations. However, they also present risks related to asset quality and management quality if not properly managed. To harness the benefits of SSCDMs while mitigating potential risks, banks must adopt robust strategies and risk management practices in line with the CAMEL framework.

Methods

This research study is descriptive and analytical, aiming to examine the financial performance of commercial banks in Tanzania before and after the utilization of SSCDMs. Structured data collection involved gathering quantitative financial data from audited financial statements of the four selected commercial banks over a six-year period (2017–2022). These data included key financial metrics such as capital adequacy ratio (CAR), cost-to-income ratio (CIR), return on assets (ROA), return on equity (ROE), and loan-to-deposit ratio (LDR). These metrics were extracted directly from official financial reports available on the banks' official websites. Semi-structured interviews were conducted to collect qualitative data. These interviews involved discussions with relevant fifteen stakeholders who possess valuable insights related to the impact of self-service cash deposit machines (SSCDMs) within the commercial banks. Four prominent Tanzanian banks were randomly chosen for a study on their market share. This random selection ensures a fair representation of commercial banks, making findings applicable to the wider banking sector. NMB is a leading bank with a strong presence in microfinance. CRDB Bank is one of the largest, serving individuals, SMEs, and corporations. NBC is a well-established bank offering a diverse range of services. Exim Bank focuses on international trade. These banks operate in various regions, collectively representing a significant portion of Tanzania's banking sector, making them ideal for studying the impact of self-service cash deposit machines (CDMs) on the performance of commercial bank.

CAMEL analysis is a widely accepted framework for assessing the overall soundness and performance of financial institutions, particularly banks [1, 12]. The acronym stands for capital adequacy, asset quality, management quality, earnings quality, and liquidity management. The researcher uses four ratios corresponding to each of these parameters to analyze and evaluate the financial performance of the selected banks. These ratios are considered standard measures for evaluating a bank's overall financial health, risk management, and performance 12. Using these ratios consistently, regulators, analysts, and stakeholders can compare banks and assess their stability and financial soundness [1] (Table 1 and 2).

Table 1 CAMEL parameters ratios used in this study. *Source*: Merchant, 2012

CAMEL parameters	Ratios
Capital adequacy	Equity to asset
Management quality	Cost-to-income
Liquidity	Net loan to total asset
Earning performance	1) Net profit to total asset
	2) Net profit to total equity

These ratings help evaluate a bank's performance and financial health based on specific criteria within each component.

Results and discussion

Capital adequacy

Impact of self-service CDMs on the capital adequacy six years' financial statements for each bank were collected from 2017 to 2022 for the capital adequacy analysis. The capital adequacy ratio (CAR) is a measure of how much capital a bank has reported as a percentage of a bank's risk-weighted credit exposures. In Table 3, the shareholders' equity-to-total assets (EQTA) as a measure of capital adequacy of selected banks from 2017 to 2022 was used. The data were extracted from audited financial statement of the four commercial banks from 2017 to 2022 (Fig. 1).

In 2017, prior to adopting SSCDMs, NMB exhibited an EQTA ratio of 22%. This ratio gradually decreased to 19% in 2018 and remained stable at 19% in 2019 and 2020. Subsequently, following the implementation of SSCDMs,

a discernible increase in the EQTA ratio was observed, reaching 21% in 2021 and maintaining this level in 2022. This signifies a positive influence of SSCDM utilization on NMB's shareholder equity.

Before embracing SSCDMs, CRDB displayed an EQTA ratio of 19% in 2017. The ratio experienced fluctuations, with a slight decrease to 16% in 2018, followed by an increase to 17% in 2019. Post-SSCDM implementation, a gradual rise in the EQTA ratio was noted, reaching 18% in 2021 and sustaining this level in 2022. This suggests a positive impact of SSCDMs on CRDB's shareholder equity.

Preceding SSCDM utilization, NBC maintained an EQTA ratio of 16% in 2017, which increased to 20% in 2018 and remained stable at 20% in 2019. However, there was a subsequent decline in the EQTA ratio after SSCDM implementation, decreasing to 11% in 2020 and further to 13% in 2021. This indicates a negative impact of SSCDMs on NBC's shareholder equity.

Before incorporating SSCDMs, EXIM Bank exhibited an EQTA ratio of 17% in 2017, gradually declining to 15% in 2018 and further to 9% in 2019. Following SSCDM utilization, an improvement in the EQTA ratio was observed, reaching 11% in 2020 and maintaining this level in 2021. This suggests a positive influence of SSCDMs on EXIM's shareholder equity.

During a recent interview with a respondent, valuable insights were gained into the impact of self-service CDMs on capital adequacy. These responses provided illumination on the influence of SSCDMs on the capital adequacy of the commercial bank.

Table 2 Rating base of CAMEL Components. *Source*: Babar and Zeb [2]

Rating components	Rating 1	Rating 2	Rating 3	Rating 4	Rating 5
Capital adequacy ratio	≥15%	12–14.99%	8–11.99%	7%–7.99	≤6.99%
Assets quality ratio	≤1.25%	≤2.5–1.26%	≤3.5–2.6%	≤5.5–3.6%	≥5.6%
Management efficiency	≤25%	30–26%	38–31%	45–39%	≥46%
Earnings capacity ROA	≥1%	0.9–0.8	0.35–0.7	0.25–0.34	≤0.24
Earnings capacity ROE	≥22%	17–21.99%	10–16.99%	7–9.99	≤6.99
Liquidity Ratio	≥50%	45–49.99%	38–44.99%	33%–37.99	≤32%

Table 3 Shareholder equity-to-total assets (EQTA) *Source*: Author's Compilation, 2023

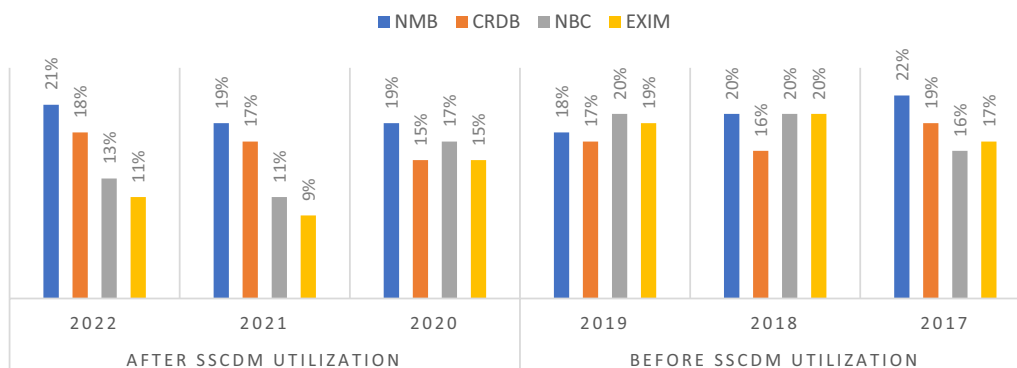|	After SSCDM Utilization (%)			Before SSCDM Utilization (%)		
	2022	2021	2020	2019	2018	2017
NMB	21	19	19	18	20	22
CRDB	18	17	15	17	16	19
NBC	13	11	17	20	20	16
EXIM	11	9	15	19	20	17

SHAREHOLDER EQUITY TO TOTAL ASSETS (EQTA)

Fig. 1 Shareholder equity-to-total assets (EQTA). *Source*: Author's Compilation, 2023

The interview responses suggest that, "*Self-service CDMs allow customers to deposit cash directly into their accounts without interacting with a bank teller, this can lead to an increase in cash deposits, potentially affecting the liquidity position of the commercial bank. While higher liquidity can be beneficial for day-to-day operations, it may also require the institution to allocate additional capital to maintain an appropriate liquidity buffer.*" (Interviewee 3, Head of Retail Banking, CRDB).

The second interview responses suggest that through self-service CDMs commercial banks increase the deposit growth. The respondent's comment that "*Self-service CDMs often encourage customers to deposit cash more frequently, leading to an increase in deposits held by the commercial bank. As deposits grow, the institution's liabilities also increase. To ensure capital adequacy, banks may need to expand their capital base proportionally to support the larger deposit base.*" (Interviewee 7, Customer service representative, EXIM).

The third interview responses suggest that through self-service CDMs commercial banks increase the operational efficiency. The respondent's comment that "*Self-service CDMs can enhance operational efficiency for commercial banks by reducing the need for manual cash handling and teller services. This efficiency improvement can lead to cost savings, potentially freeing up capital that could be deployed elsewhere to support the institution's overall capital adequacy.*" (Interviewee 5, Head of Operation, NMB).

Profitability of commercial banks

The efficiency of bank management is often assessed through various performance metrics. One crucial metric is the cost-to-income ratio (COSR), which measures the total operating expenses as a proportion of the total operating income (Fig. 2 and Table 4). Cost-to-income ratio can be calculated with the following formula:

$$\text{Cost to Income Ratio} = \left(\frac{\text{Operating Cost}}{\text{Operating Income}} \right) \times 100$$

Before the utilization of SSCDMs in 2017, NMB had a cost-to-income ratio (CIR) of 58.0%. The CIR increased steadily over the following years, reaching 60.0% in 2019. However, after the implementation of SSCDMs, there was a significant surge in the CIR to 69.3% in 2020, 72.0% in 2021, and further to 75.34% in 2022. This indicates a notable negative impact of SSCDM utilization on NMB Bank's profitability. Prior to SSCDM utilization in 2017, CRDB's CIR was 66.7%. The ratio experienced slight fluctuations but remained relatively stable. After the adoption of SSCDMs, the CIR showed a marginal increase to 67.6% in 2020, followed by a slight decrease in subsequent years, reaching 70.23% in 2022. Overall, the impact of SSCDM utilization on CRDB Bank's profitability appears relatively stable.

Before the use of SSCDMs in 2017, NBC had a CIR of 57.0%. The CIR increased marginally over the following years. However, after incorporating SSCDMs, there was a significant rise in the CIR to 61.5% in 2020, 62.6% in 2021, and further to 65.9% in 2022. This suggests a notable negative impact of SSCDM utilization on NBC Bank's profitability. Preceding SSCDM utilization in 2017, EXIM Bank had a CIR of 51.0%. The ratio increased gradually over the next two years. After the adoption of SSCDMs, there was a more pronounced increase in the CIR to 58.0% in 2020, 59.0% in 2021, and further to 62.2% in 2022. This indicates a notable negative impact of SSCDM utilization on EXIM Bank's profitability.
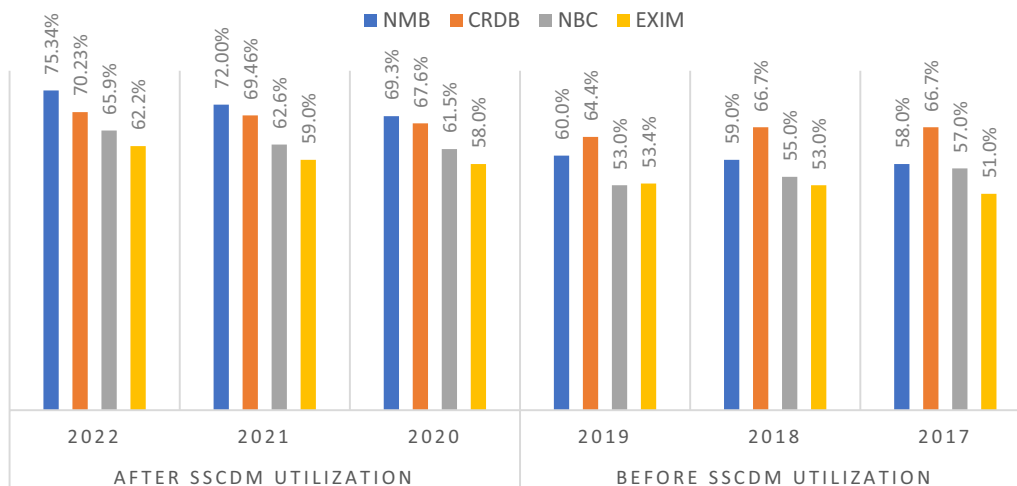
MANAGEMENT EFFICIENCY

Fig. 2 Management efficiency ratios. *Source*: Author's Compilation, 2023

Table 4 Cost-to-income ratio and the bank's profitability. *Source*: Author's Compilation, 2023

	After SSCDM Utilization (%)			Before SSCDM Utilization (%)		
	2022	2021	2020	2019	2018	2017
NMB	75.34	72.00	69.3	60.0	59.0	58.0
CRDB	70.23	69.46	67.6	64.4	66.7	66.7
NBC	65.9	62.6	61.5	53.0	55.0	57.0
EXIM	62.2	59.0	58.0	53.4	53.0	51.0

In summary, the utilization of SSCDMs seems to have a negative impact on the profitability of the banks, as indicated by the increase in the cost-to-income ratio after their implementation. The extent of the impact varies among the banks, with some experiencing more significant changes than others.

In response to our inquiry about impact of self-service CDMs on the commercial bank's earnings, the interviewee's response emphasized as follows:

The first interview responses suggest that, *Self-service CDMs can help commercial banks reduce operating costs. By automating the cash deposit process, banks can decrease the need for manual labor and the associated expenses. They can also reduce the reliance on tellers, which can result in staffing cost savings. This improved operational efficiency can contribute to higher profitability by reducing overall expenses.* (Interviewee 6, Compliance Officers, NMB).

The second interview responses suggest that self-service CDMs increased customer convenience. The respondent's comment that "*Self-service CDMs provide customers with greater convenience and flexibility for*

depositing cash. This convenience can attract more customers to the institution, potentially leading to an increase in deposit volumes. Higher deposit volumes can generate additional revenue for the commercial bank, particularly through interest income and fees associated with deposit accounts." (Interviewee 8, Technology vendor, EXIM).

The third interview responses suggest that self-service CDMs provide a cross-selling opportunities. The respondent's comment that "*Self-service CDMs provide an opportunity for commercial banks to promote their other products and services. While customers are using the machines, the bank can display targeted advertisements or offer promotions for credit cards, loans, or investment products. This cross-selling potential can contribute to increased revenue and profitability.*" (Interviewee 2, Chief Operations Officers, NBC).

Impact of self-service CDMs on the commercial bank's earnings

Earning capacity is the net average earnings at a given moment in time: past, current or future. Earning ability

can be measured using return on asset (ROA) and return on equity (ROE).

Return on assets

This is a financial ratio whose role is to display the percentage of profit which a bank gains against its entire capital investment. It is rather known as net income (or pretax profit)/total assets. ROA is a profitability ratio (Fig. 3 and Table 5). This ratio measures the earning per shilling of assets invested in the company. A high ratio represents better the bank financial performance is as follows:

The return on assets formula is presented as net profit/ total assets.

In 2017, before SSCDM utilization, NMB had a return on assets (ROA) of 2%. The ROA slightly increased in the subsequent years, reaching 3% in 2019. After the implementation of SSCDMs, there was continued improvement in the ROA, reaching 3% in 2020, 3% in 2021, and further increasing to 4% in 2022. This suggests that the utilization of SSCDMs had a positive impact on NMB Bank's profitability as measured by return on assets. Prior to SSCDM utilization in 2017, CRDB had a ROA of 1%. The ROA increased steadily in the following years, reaching 3% in 2019. After the adoption of SSCDMs, there was

sustained improvement in the ROA, reaching 3% in 2020, 3% in 2021, and further increasing to 4% in 2022. This indicates that the utilization of SSCDMs had a positive impact on CRDB Bank's profitability in terms of return on assets.

Before SSCDM utilization, NBC had a ROA of 1% in 2017, which increased to 1% in both 2018 and 2019. After incorporating SSCDMs, there was some fluctuation in the ROA, with 1% in 2020, a decline to -1% in 2021, and a recovery to 3% in 2022. These variations suggest that the utilization of SSCDMs had a mixed impact on NBC Bank's profitability in terms of return on assets. Preceding SSCDM utilization in 2017, EXIM Bank had a ROA of 1%. The ROA remained relatively stable, with 0% in 2018 and -1% in 2019. After implementing SSCDMs, there was an improvement in the ROA, reaching 2% in both 2020 and 2021, and further increasing to 3% in 2022. This suggests that the utilization of SSCDMs had a positive impact on EXIM Bank's profitability as measured by return on assets.

The interview findings enrich understanding of SSCDM in earning ability on ROA of the commercial bank. The interviewee's response emphasized as follows:

The first interview responses suggest that *Self-service CDMs can improve cost efficiency for commercial*
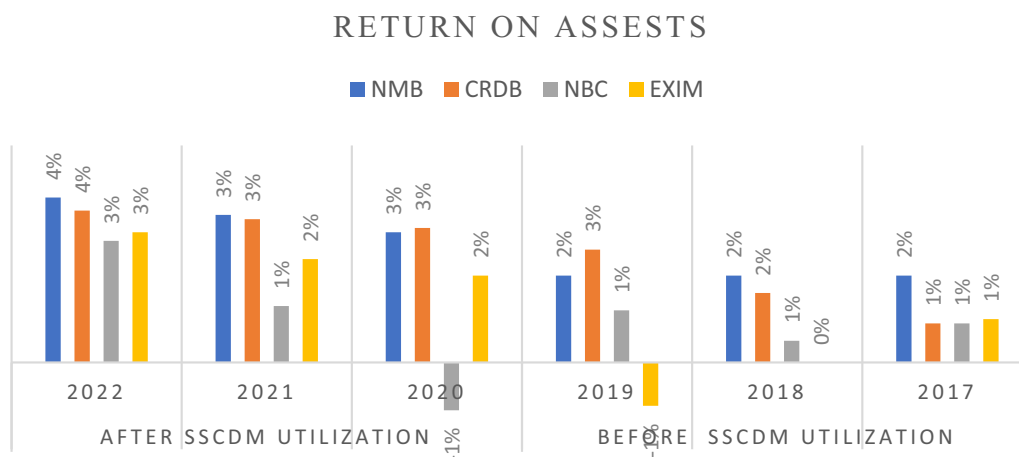

Fig. 3 Earning ability of the commercial banks (ROA). *Source*: Author's Compilation, 2023

Table 5 Return on assets ratios *Source*: Author's Compilation, 2023

	After SSCDM Utilization (%)			Before SSCDM Utilization (%)		
	2022	2021	2020	2019	2018	2017
NMB	4	3	3	2	2	2
CRDB	4	3	3	3	2	1
NBC	3	1	−1	1	1	1
EXIM	3	2	2	−1	0	1

banks by reducing the need for manual cash handling and teller services. These machines automate the cash deposit process, leading to cost savings in terms of labor and operational expenses. The reduction in costs can positively impact the ROA by improving the efficiency of asset utilization. (Interviewee 12, Experts in Banking Automation, NMB).

The second interview responses suggest that self-service CDMs increased deposit volumes. The respondent's comment that "*Self-service CDMs can attract more customers to deposit cash due to their convenience. This can lead to increased deposit volumes, providing commercial banks with a larger pool of funds to lend or invest. Higher earning assets, coupled with efficient cost management, can contribute to an improved ROA.*" (Interviewee 14, Customer Service Representative, EXIM).

The third interview responses suggest that self-service CDMs can increase the income. The respondent's comment that "*Commercial banks often charge fees for using self-service CDMs. These fees can generate additional revenue streams, contributing to overall profitability. The fees earned from these machines can positively impact the ROA by boosting income without*

a corresponding increase in assets." (Interviewee 9, Head of Operation, EXIM).

Return on equity

This ratio measures profitability of equity fund invested the company. It also measures how profitably owner's funds have been utilized to generate the company's revenues (Fig. 4 and Table 6). A high ratio represents how better the company is. It is calculated by the **Formula: Profit after Tax ÷ Net worth,** where Net worth = Equity share capital, and reserve and surplus.

In 2017, before SSCDM utilization, NMB had a return on equity (ROE) of 12%. The ROE gradually increased to 15% in 2019 and further to 18% in 2020. After implementing SSCDMs, there was a significant improvement in the ROE, reaching 25% in both 2021 and 2022. This suggests that the utilization of SSCDMs had a positive impact on NMB Bank's profitability in terms of return on equity. Prior to SSCDM utilization in 2017, CRDB had a ROE of 5%. The ROE increased to 8% in 2018 and further to 14% in 2019. After implementing SSCDMs, there was continued improvement in the ROE, reaching 16% in 2020, 25% in 2021, and further to 26% in 2022. This indicates that the utilization of SSCDMs had a positive
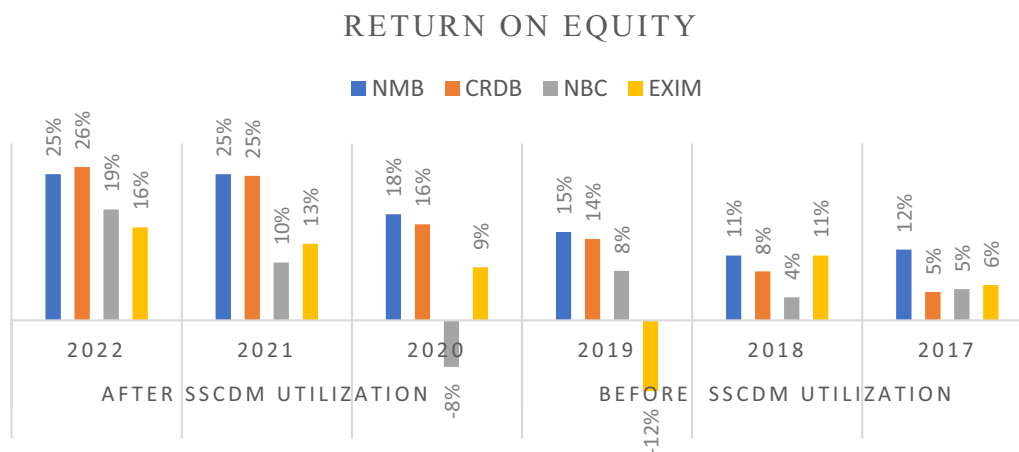

Fig. 4 Earning ability of the commercial banks (ROE). *Source*: Author's Compilation, 2023

Table 6 Return on equity ratios *Source*: Author's compilation, 2023

	After SSCDM utilization (%)			Before SSCDM utilization (%)		
	2022	**2021**	**2020**	**2019**	**2018**	**2017**
NMB	25	25	18	15	11	12
CRDB	26	25	16	14	8	5
NBC	19	10	−8	8	4	5
EXIM	16	13	9	−12	11	6

impact on CRDB Bank's profitability in terms of return on equity.

Before SSCDM utilization, NBC had a ROE of 5% in 2017. The ROE increased to 8% in 2019 but experienced negative returns in 2018 and 2020. After implementing SSCDMs, there was a mixed impact on NBC Bank's ROE, with a decline to -8% in 2020, followed by a recovery to 10% in 2021 and further improvement to 19% in 2022. These fluctuations suggest that the utilization of SSCDMs had a varied impact on NBC Bank's profitability in terms of return on equity. Preceding SSCDM utilization in 2017, EXIM Bank had a ROE of 6%. The ROE increased to 11% in 2018 and further to 9% in 2019. After implementing SSCDMs, there was continued improvement in the ROE, reaching 13% in 2021 and further to 16% in 2022. This suggests that the utilization of SSCDMs had a positive impact on EXIM Bank's profitability in terms of return on equity.

In summary, the utilization of SSCDMs appears to have a generally positive impact on the profitability of the banks, as indicated by the improvement in return on equity over the years after their implementation.

The interview findings enrich understanding of SSCDM in earning ability on ROE of the commercial bank. The interviewee's response emphasized as follows:

The respondent's comment that *"Self-service CDMs can improve cost efficiency for commercial banks by reducing manual cash handling and teller services. This automation leads to cost savings, including labor expenses and operational costs. By reducing expenses, commercial banks can enhance their profitability and, consequently, their ROE."* (Interviewee 1, Head of Operation, NBC).

The respondent's comment that *"Self-service CDMs can attract more customers to deposit cash due to their convenience. This can result in increased deposit volumes, providing commercial banks with a larger asset base. Higher asset levels, coupled with efficient cost management, can contribute to improved profitability and ROE."* (Interviewee 15, IT Managers, NMB).

The respondent's comment that *"Commercial banks often charge fees for using self-service CDMs. These fees generate additional revenue streams that can contribute to profitability and ROE. The fee income earned from*

these machines can enhance ROE by increasing overall income without a corresponding increase in equity." (Interviewee 11, Heads of Retail Banking, CRDB).

Effect of self-service CDMs on the liquidity position

The loan-to-deposit ratio (LDR) is used to assess a bank's liquidity by comparing a bank's total loans to its total deposits for the same period (Table 7 and Fig. 5). The LDR is expressed as a percentage. If the ratio is too high, it means that the bank may not have enough liquidity to cover any unforeseen fund requirements.

Formula and Calculation for LDR

$$LDR = \frac{\text{Total Loans Granted}}{\text{Total Deposits}}$$

In 2017, before SSCDM utilization, NMB had an LDR of 68%. The LDR increased to 78% in 2018 and further to 83% in 2021. After implementing SSCDMs, there was a continued increase in the LDR, reaching 87% in 2022. This suggests that the utilization of SSCDMs had a positive impact on NMB Bank's liquidity as measured by the loan-to-deposit ratio.

Prior to SSCDM utilization, CRDB had an LDR of 57.9% in 2017. The LDR increased to 60.2% in 2018 and further to 72.3% in 2020. After implementing SSCDMs, there was a significant increase in the LDR, reaching 75.3% in 2021 and further to 82.32% in 2022. This indicates that the utilization of SSCDMs had a positive impact on CRDB Bank's liquidity in terms of the loan-to-deposit ratio.

Before SSCDM utilization, NBC had an LDR of 69.7% in 2017. The LDR increased to 75.1% in 2019 but experienced fluctuations in subsequent years. After implementing SSCDMs, there was a mixed impact on NBC Bank's LDR, with a decline to 63.8% in 2020, followed by an increase to 72.63% in 2021 and further improvement to 77.43% in 2022. These fluctuations suggest that the utilization of SSCDMs had a varied impact on NBC Bank's liquidity in terms of the loan-to-deposit ratio.

Prior to SSCDM utilization, EXIM Bank had an LDR of 78.6% in 2017. The LDR decreased to 69% in 2021 but remained relatively stable in other years. After

Table 7 Liquidity (loan-to-deposit ratio) *Source*: Author's Compilation, 2023

	After SSCDM Utilization (%)			Before SSCDM Utilization (%)		
	2022	2021	2020	2019	2018	2017
NMB	87	83	78.0	73.0	78.0	68.0
CRDB	82.32	75.30	72.3	38.6	60.2	57.9
NBC	77.43	72.63	63.8	75.1	65.9	69.7
EXIM	73	69	71.0	69.0	77.0	78.6

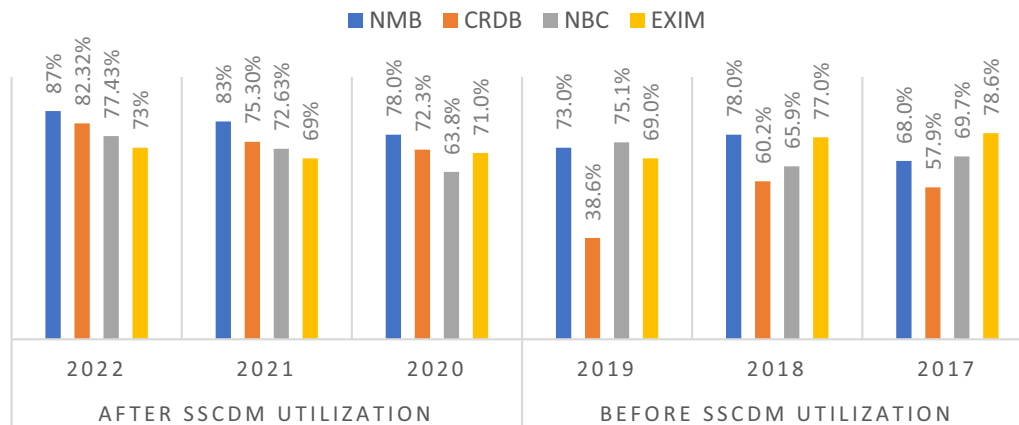## LIQUIDITY POSITION

■ NMB ■ CRDB ■ NBC ■ EXIM

Fig. 5 Liquidity position (Loan-to-Deposit Ratio). *Source*: Author's Compilation, 2023

implementing SSCDMs, there was an improvement in the LDR, reaching 71% in 2020, 69% in 2021, and further to 73% in 2022. This suggests that the utilization of SSCDMs had a positive impact on EXIM Bank's liquidity in terms of the loan-to-deposit ratio.

Overall, the findings indicate that the impact of SSCDM utilization on liquidity, as measured by the loan-to-deposit ratio, varied among the banks in Tanzania. NMB, CRDB, and EXIM experienced positive effects, with an increase in their LDR ratios after implementing SSCDMs. NBC saw some fluctuations, with a mix of improvements and declines in the LDR. According to Babar and Zeb [2] from Table 2 rating base of CAMEL components, the liquidity position ratio of the bank before and after the utilization of self-service cash deposit machines is considered to be strong for NMB and EXIM bank from 2017–2022. However, for CRDB bank in 2016 (before the utilization of self-service cash deposit machines), the liquidity position ratio was considered unsatisfactory at the ratio of 11.6%. As shown in Table 7 above, with regard to CRDB after SSCDM utilization, the liquidity position ratio was 38.6% in 2019 which is considered as fair rating.

Based on the interview question regarding Self-service cash deposit machines (CDMs) can have a notable impact on the liquidity position of commercial banks. Here are a few key ways in which they can affect liquidity as highlighted by the interview respondents:

The respondent's comment that *"Self-service CDMs allow customers to deposit cash directly into their accounts without interacting with a bank teller. This convenience can lead to an increase in cash deposits. As the volume of cash deposits grows, it can affect the liquidity position of the commercial bank. A higher inflow of cash*

can potentially enhance the institution's liquidity position, as it increases the available funds for lending and meeting customer withdrawal demands" (Interviewee 5, Head of Operation, NMB).

The respondent's comment that *"Self-service CDMs can contribute to deposit stability, particularly for cash-intensive businesses and individuals. By offering easy access to deposit cash, commercial banks can attract customers who rely on cash transactions. Stable deposits provide a reliable source of funding for the institution, promoting liquidity."* (Interviewee 15, IT Managers, NMB).

The respondent's comment that *"Self-service CDMs automate the cash deposit process, reducing the need for manual cash handling by bank tellers. This improved efficiency can help commercial banks manage their cash flows more effectively, ensuring that they have the appropriate level of liquidity to meet customer demands."* (Interviewee 14, Customer Service Representative, EXIM).

Multicollinearity test

Multicollinearity is present when two or more predictors within a model are correlated and provide repetitive information about the response variable. It can be assessed using inflation variance and resistance factors (IFVs). If the VIF value exceeds 4.0 or the tolerance value falls below 0.2, it indicates the presence of multicollinearity, as suggested by Hair (Table 8), Black, Babin, and Anderson (2010).

According to the table, all items have a tolerance value greater than 0.20. Additionally, none of the items have a value exceeding 4. These findings suggest the absence of collinearity, indicating that each item provides unique and non-redundant information. This further supports

Table 8 The variance inflation factor and tolerance

Model	Collinearity statistics		
		Tolerance	VIF
1	(Constant)		
	Capital adequacy	.553	1.809
	Management efficiency	.332	3.015
	ROA	.701	1.426
	ROE	.465	2.152
	Liquidity	.629	1.589

Table 9 Regression analysis

Model	R	R Square	Adjusted R Square	Std. error of the estimate
1	.847[a]	.757	.656	.34184

Predictors: (Constant), Capital adequacy, Management efficiency, ROA, ROE, Liquidity[a]

the notion that each item distinctly represents different aspects of the conceptual model (Table 9).

Regression analysis

The coefficient of determination, also known as R-squared, indicates the proportion of the variance in the dependent variable that can be explained by the independent variables in the model. In this analysis, R is reported as 0.847. It suggests that approximately 84.7% of the variance in the dependent variable can be explained by the independent variables included in the model.

This is another representation of the coefficient of determination. R Square is calculated by squaring the value of R. In this case, the R Square value is 0.757, indicating that around 75.7% of the variance in the dependent variable is explained by the independent variables. Adjusted R Square considers the number of predictors in the model and adjusts the R Square value accordingly. It penalizes the inclusion of unnecessary predictors. The adjusted R Square in this analysis is reported as 0.656.

This measure represents the average deviation between the observed values of the dependent variable and the predicted values from the regression model. It indicates the accuracy of the predictions made by the model. In this case, the standard error of the estimate is reported as 0.34184.

The regression analysis suggests that the independent variables (Capital adequacy, Management efficiency, ROA, ROE, and Liquidity) collectively explain a significant portion of the variance in the dependent variable. The model has a reasonably high R Square value, indicating a good fit. However, it is important to consider the context of the analysis and the specific research question to properly interpret and evaluate the regression results (Table 10).

Regression analysis—coefficients

The table provided presents the unstandardized coefficients, standardized coefficients (also known as beta coefficients), t values, and p values for each predictor in the regression model.

The constant term represents the intercept of the regression model. In this analysis, the unstandardized coefficient is reported as 0.731, indicating that when all predictor variables are zero, the estimated mean value of the dependent variable is 0.731. The t value of 2.111 suggests that the constant term is statistically significant at the 0.05 significance level ($p = 0.039$). The unstandardized coefficient for capital adequacy is 0.022, which indicates that a one-unit increase in capital adequacy is associated with a 0.022 unit increase in the dependent variable (assuming all other variables are held constant). The standardized coefficient (beta) of 0.029 suggests that capital adequacy has a small positive effect on the dependent variable. The t value of 0.303 and the p value of 0.000 indicate that the coefficient is not statistically significant.

The unstandardized coefficient for management efficiency is 0.068, implying that a one-unit increase in management efficiency corresponds to a 0.068 unit increase in the dependent variable (controlling for other

Table 10 Regression analysis—coefficients

Model		Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	Std. error	Beta		
1	(Constant)	.731	.346		2.111	.039
	Capital adequacy	.022	.074	.029	.303	.000
	Management efficiency	.068	.112	.076	.607	.002
	ROA	.064	.074	.075	.875	.015
	ROE	.125	.092	.143	1.356	.011
	Liquidity	.111	.071	.141	1.556	.004

variables). The standardized coefficient (beta) of 0.076 indicates a small positive effect of management efficiency on the dependent variable. The t value of 0.607 and the p value of 0.002 suggest that the coefficient is statistically significant. The unstandardized coefficient for return on assets (ROA) is 0.064, indicating that a one-unit increase in ROA is associated with a 0.064 unit increase in the dependent variable (assuming other variables remain constant). The standardized coefficient (beta) of 0.075 suggests a small positive effect of ROA on the dependent variable. The t value of 0.875 and the p value of 0.015 indicate that the coefficient is statistically significant.

The unstandardized coefficient for return on equity (ROE) is 0.125, implying that a one-unit increase in ROE corresponds to a 0.125 unit increase in the dependent variable (controlling for other variables). The standardized coefficient (beta) of 0.143 indicates a moderate positive effect of ROE on the dependent variable. The t value of 1.356 and the p value of 0.011 suggest that the coefficient is statistically significant. The unstandardized coefficient for liquidity is 0.111, indicating that a one-unit increase in liquidity is associated with a 0.111 unit increase in the dependent variable (assuming other variables are held constant). The standardized coefficient (beta) of 0.141 suggests a moderate positive effect of liquidity on the dependent variable. The t value of 1.556 and the p value of 0.004 indicate that the coefficient is statistically significant.

Conclusions

In conclusion, this study has yielded crucial insights into the impact of self-service cash deposit machines (SSCDMs) on the financial performance of Tanzanian commercial banks. Employing a mixed-method research design, encompassing quantitative metrics such as capital adequacy ratio (CAR), cost-to-income ratio (CIR), return on assets (ROA), return on equity (ROE), and loan-to-deposit ratio (LDR), alongside qualitative assessments of operational changes, customer behavior, and marketing strategies; our analysis aimed to comprehensively understand the multifaceted effects of SSCDM adoption in the banking sector.

While positive impacts were observed for some banks, it is imperative to acknowledge that others experienced negative or mixed effects. These variations can be attributed to factors such as diverse SSCDM adoption strategies, discrepancies in customer adoption rates, and variations in the effectiveness of marketing and customer education efforts. External influences, including shifts in the economic and regulatory landscape, may have further contributed to differing outcomes among banks.

Analyzing the specific impacts on financial metrics reveals distinctive patterns. The equity-to-total assets (EQTA) ratio, cost-to-income ratio (CIR), return on assets (ROA), return on equity (ROE), and loan-to-deposit ratio (LDR) each demonstrated unique trends for the banks under consideration.

NMB exhibited a notable increase in EQTA ratio after SSCDM utilization, whereas CRDB and EXIM Bank experienced positive trends. NBC faced a decline in EQTA ratio, indicating a negative impact. In terms of CIR, NMB and EXIM Bank saw significant rises, while CRDB maintained relative stability. NBC and CRDB exhibited an increase in CIR, reflecting negative impacts. Regarding ROA, NMB and CRDB demonstrated consistent improvement, whereas NBC's ROA exhibited mixed results. EXIM Bank experienced a notable increase. ROE showcased substantial improvement for NMB and CRDB, while NBC's ROE had fluctuations, and EXIM Bank experienced a positive impact. LDR exhibited positive trends for NMB and CRDB, with NBC showing fluctuations and EXIM Bank improvement.

Regression analysis supported these findings, underscoring the collective impact of capital adequacy, management efficiency, ROA, ROE, and liquidity on the dependent variable. Despite variations among banks, the overall trends reflected both positive and negative influences on profitability and liquidity.

Implications for the Tanzanian banking sector are significant. To mitigate potential negative impacts, banks are advised to prioritize a customer-centric approach, invest in customer education and robust marketing strategies, and ensure seamless integration of SSCDMs into existing technology infrastructure.

Recommendations for future research include long-term studies tracking SSCDM adoption, comparative analyses across different sectors or regions, and investigations into the customer experience and cybersecurity aspects of SSCDM adoption. Further advocacy for future research using the updated CAMELS framework could also be valuable. These insights aim to guide informed decision-making and strategic planning for banks venturing into or expanding their SSCDM capabilities.

Abbreviations

ATMs	Automated teller machines
CAR	Capital adequacy ratio
CDMs	Cash deposit machines
COSR	Cost-to-income ratio
CRDB	Cooperative and rural development bank
EQTA	Shareholders' equity-to-total assets
LDR	Loan-to-deposit ratio
NBC	National bank of commerce
NMB	National microfinance bank
SSCDMs	Self-service cash deposit machines

Declarations

Ethics approval and consent to participate
Throughout the study, the researcher carefully addressed ethical considerations, including maintaining the anonymity of respondents, ensuring the confidentiality of responses, and upholding integrity in handling the collected data and information. Moreover, the researcher was committed to reporting the findings from the study with sincerity. The presentation of the results was conducted in a manner that respected the privacy of the respondents and refrained from disclosing their identities.

Consent of publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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