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Transforming Parking Systems: Exploring the Role of Manless Systems and Digitalization in Improving Operational Performance

Ryan Yudhistira Maulana, Leonard Adrie Manafe, Safaat
[1,2,3]Management, Sekolah Tinggi Ilmu Ekonomi Mahardhika
[1]ryanyudistira226@gmail.com*, [2]leonard.adrie@stiemahardhika.ac.id, safaat@stiemahardhika.ac.id

Abstract

This study investigates, through practical measures, how the implementation of an unattended parking system at Semen Gresik Hospital has been able to boost the operational efficiency of the parking area. The system utilises automatic sensors, a mobile application, and a digital payment mechanism to address the acute problem of vehicle congestion in the hospital grounds. Data collection employed a qualitative approach and case study methodology; six informants from diverse fields were interviewed in depth to capture varied perspectives. Field findings revealed that parking search times decreased significantly and payment processes became faster, although sporadic sensor malfunctions and initial user anxiety regarding touchscreens remained as challenges. Physical queues have also decreased, and parking space utilisation has become more efficient; however, infrastructure improvements and additional public awareness campaigns remain essential. The study highlights the potential of digital technology in the healthcare sector and underscores the importance of regular technical maintenance and ongoing user education. Researchers recommend conducting similar experiments in other locations, with a greater focus on sustainability and how users can adapt to evolving technology.

Keywords: Manless Parking System, Digital Technology, Hospital Operational Efficiency, Smart Parking, Technology Integration

1. Introduction

Introducing unmanned parking facilities at Semen Gresik Hospital stands to cut wait times noticeably and lighten the daily traffic crush in the lots. The move would free up staff and push most car handling straight into an app or touchscreen, letting patients and visitors manage their arrival on the fly. Smart parking systems increasingly rely on mobile interfaces that let drivers check space availability, make reservations, and complete payments from their phones. [1] argue that such applications cut both the minutes spent hunting for a spot and the tailpipe emissions that accompany that fruitless search. Game theory offers a different lens. [2] model each arriving car as a player in a parking lottery, seeking a Nash equilibrium that distributes slots fairly and quickly across the crowd. Machine learning researchers have served up predictive firepower, too. Zeng and colleagues tout a stacked GRU-LSTM architecture that ingests weather, calendar, and historical data to forecast occupancy with unusual precision, a gain they say frees up managers to allocate resources rather than chase guesses [3] . [4] build on that insight through a two-level grid algorithm that matching supply to demand while trimming the direct costs borne by users. Finally, [5] combine IoT sensors with adaptive learning engines to automate space oversight, peeling human operators away from routine checks and leaving them free for edge cases. Permit reservation frameworks, a concept detailed by Han, have been shown to sequence vehicle entries more effectively while also swelling overall occupancy within hospital lots [6]. In a complementary vein, Tran and co-authors apply mixed-integer linear programming to marry demand with operating costs, thus averting localized jams and stretching available stalls farther than if pricing were static [7]. Together these algorithmic levers hint at a digital overhaul that could smooth arrivals at Semen Gresik Hospital and leave patients and staff feeling less harried.

Fully automated parking systems-cameras, IoT sensors and mobile apps working in concert-eliminate the need for on-site attendants. By doing away with cashiers and gatekeepers, managers slash payroll, speed up vehicle movements, and squeeze more cars into the same footprint. Researchers have noted that smart-parking algorithms, which ingest location data every second, direct drivers straight to an open bay. As a consequence, vehicles spend less time circling and exhaust emissions drop almost immediately [8] [9] [10] [11]. Ultrasonic sensors paired with Bluetooth transmitters relay stall status to a cloud dashboard, allowing customers to check availability while still

three blocks away. That advance alone trims minutes from the hunt for a space [12]. Cameras that read license plates automatically raise barriers on entry and exit, which significantly tightens security and further limits human touch-points [13] [14]. In a busy hospital, applying this technology can clear traffic bottlenecks, boost occupancy by matching supply with demand, and leave patients and visitors saying the arrival experience was smoother than expected. High-traffic venues, hospitals most of all, see immediate gains when ordinary parking routines are replaced by automated systems; the vehicles vanish quickly, and nursing stations do not skip a beat [10] [15]. Still, success hinges on laying the right cables and curbing old habits, a double-barreled task, because few drivers walk up to the kiosk already fluent in gesture commands or smartphone shortcuts [16] [17]. Once those hurdles are cleared, inter-networked sensors and cloud dashboards can redraw the daily parking script, turning a bottleneck into a walk-in, call-out, and-go experience [11] [15].

Deploying driver-less parking technology in a hospital setting is far from a plug-and-play affair; the blend of urgency, high traffic, and medical protocols that defines a healthcare campus forces engineers to think on their feet. Unlike malls or apartment towers, a day at the ER can turn any lot into a crush within minutes, so custom algorithms, not off-the-shelf apps, become the new baseline. In that spirit, Ji and colleagues worked out a space-allocation scheme rooted in cumulative-prospect thinking that nudges parkers-who, after all, are only partially rational-in the middle of rushed decision-making. When the tweak is dropped into the code, occupancy ticks up and, by extension, the money side of the ledger begins to brighten [18]. Recent research points to RFID-enabled health-monitoring platforms as a game-changer for hospital operations, extending into parking logistics by automating record-keeping and minimizing human error [19]. Such systems promise sharper efficiency and tighter security. Floroian has mapped similar gains in cloud-based data-in-motion across smart hospitals, showing how uninterrupted departmental exchanges could also streamline vehicular entry and exit on-site [20]. That line of inquiry dovetails with parallel work on camera-driven occupancy detection; the engineers behind the OcpDet framework tout an adaptable, high-accuracy feed that reinvents space management in high-traffic locales like medical centers [21]. Jemmali tests intelligent routing algorithms at vaccine depots and finds they absorb volume spikes without sacrificing safety the same logic transfers neatly to hospital lots [22]. Meanwhile, Geridipudi prototypes an IoT surveillance mesh that automates fee collection and head counting, slicing manual overhead and promising a frictionless visitor experience [23]. Together, the recent literature indicates that fully automated parking facilities-institutions such as Semen Gresik Hospital, where throughput is often a concern-can alleviate congestion and logistical strain by deploying cooperative parking algorithms, real-time surveillance networks, and Internet-of-Things sensors that fine-tune space allocation and quicken entry for both caregivers and visitors.

The issues addressed in this study are divided into two main areas of interest. First, the researchers seek to explore the operational constraints that arose when Semen Gresik Hospital tested an unattended parking system. Second, the second question concerns the role of digital technology: which tools and applications can reduce these constraints while promoting greater efficiency. Within a broader framework, the research objectives are both diagnostic and evaluative. The researcher aims to identify concrete problems faced and measure the positive or negative impacts of adopting digital solutions. From these findings, it is hoped that hospital management will gain practical insights before proceeding with a full-scale launch. In addition to providing direct benefits to the hospital, this study is also intended as a reference for academics interested in investigating parking digitalisation in other healthcare settings. In other words, the fieldwork to be conducted here is not merely a local experiment, but a collective contribution to a relatively scarce literature. If all goes well, the user experience at the parking stage will be much smoother.

The use of private cars and official vehicles in hospital environments has skyrocketed in recent years. This surge risks slowing down medical and administrative activities if not addressed first. Something must be done. From experience, a well-organised parking system reduces congestion and shortens waiting times for visitors, nurses and patients alike. Such convenience is not merely a number; it directly impacts the peace of mind of those in a stressful environment. This research aims to bridge the gap between daily complaints and data-driven solutions. Certain hospitals, for example, are often overwhelmed by peak arrivals, making manual management of parking slots impossible. This is where digital technology comes in IoT, mobile apps, and smart sensors. These tools can automate projection steps while providing users with real-time information about availability. Smarter management not only speeds up the physical movement of vehicles but also gives staff valuable time for more urgent healthcare tasks.

In the early stages of this investigation, researchers realised that there were not many studies covering driverless parking systems in hospital environments. Almost all existing research focused on office buildings, residential complexes, or other business areas, while medical facilities were left out of the discussion. From there, the intention arose to address this gap and observe firsthand how digital technology could function in the parking lot of Semen

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Gresik Hospital. The analysis not only encompassed the efficiency benefits promised but also the practical challenges that management must overcome when implementing the system.

This study introduces methodological updates by utilising a qualitative case study framework at Semen Gresik Hospital. The research aims to identify, explain, and explore the concrete obstacles that arise when unmanned parking technology is integrated into the healthcare facility ecosystem. In addition to problem mapping, the evaluation of the impact of digital innovation implementation on operational efficiency and user experience also serves as the focus of exploration. The findings present a fresh perspective in discussions about hospital technology implementation, a topic that has remained relatively under-explored in academic literature.

2. Research Methods

This study employs a qualitative approach and is designed as a case study at Semen Gresik Hospital. The objective is to explore how a digital manless parking system is implemented and to what extent it influences the operational efficiency of the hospital's parking system. The hospital was selected as the study location due to the high vehicle density in the campus area, which often causes traffic congestion and makes it difficult for patients and visitors to find available parking spaces. The proposed solution is unmanned parking technology, which is believed to maximise land use, reduce search time, and improve overall efficiency. An exploratory method was used to identify challenges and alternatives offered by the digital system itself. During data collection, the researcher interviewed six informants from diverse backgrounds. The first informant was the hospital facility manager responsible for daily parking operations. The second informant was from the technical team responsible for sensor installation and application management. The third informant was a staff member who managed vehicle flow on-site, while the fourth was a regular patient who frequently used the parking facility. The fifth informant was a parking user who regularly parked their vehicle at the hospital premises. The sixth informant was the head of the information technology unit, responsible for ensuring the digital interface in the parking booth functioned flawlessly. To gain a deeper understanding of concrete experiences, the researcher conducted face-to-face interviews, exploring the challenges, satisfaction, and improvements perceived by the two informants. Direct observations in the field supported the question-and-answer sessions, while administrative documents, daily reports, and other written studies provided the necessary secondary data.

Field data collection in this study relied on three basic techniques: in-depth interviews, direct observation, and document review. First, in-depth interviews were scheduled with various informants, ranging from inpatient staff to parking managers, so that everyday obstacles could be heard without censorship. Second, direct observation approached the unmanned parking machines themselves, allowing researchers to notice anomalies that are often hidden in recordings or notes. Third, document analysis referred to operational reports, software manuals, and journal articles reviewing similar technology classifications, in order to place field findings within a broader historical context. All data is then analysed using thematic analysis, which involves tracing recurring patterns from verbal conversations and field notes. These patterns are categorised into technical issues, user resistance, and efficiency improvements. This categorisation is not merely statistical jargon but a tool to reveal the true face of the manless parking system at Semen Gresik Hospital. Ultimately, this picture shows how digital devices, despite their imperfections, can mitigate many of the complexities that have long hindered the smooth operation of the hospital.

3. Results and Discussions

At Gresik Semen Hospital, the driverless parking system encounters persistent difficulties, most of which stem from excessive vehicle flows during the facilities busiest windows of the day. Even though the technology was supposed to automate and streamline parking, the underlying hardware proves too lightweight for the morning and midday surges, clogging entrances and forcing drivers to circle the lot until space finally opens. Gresik Semen Hospital is hardly alone in its parking mess; most urban garages-from crowded downtown decks to Saturday-morning malls-report the same standstill [24] [25]. Outdated wiring and weather-frazzled sensors only make things worse, telling drivers the last open slot is still there when a pickup truck has already claimed it [26]. A handful of labs are tinkering with fancier fixes, such as IoT-linked cameras and facial recognition gates that cut paperwork in half, but those gadgets have yet to leave the prototype bench [14]. For now, most visitors fumble with touch-screen payments because no one bothered to show them the ropes; even a quick handout would beat the anxious silence that fills the lobby when nothing lights up [26]. Several researchers have floated a simpler win: an overhead scoreboard that shouts how many stalls are free and points to the nearest row, thus steering traffic before it bottlenecks at the entrance [27]. Others swear by machine-learning forecasts, like the ST-GBGRU model, which can usually smell a Friday rush hours in advance and nudge staff to open extra shifts [28]. Tackling the mess, it turns out, means wiring the lot, retraining the staff, and teaching users the app before handing them the keys.

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Recent advances in digital technology in particular the deployment of IoT driven smart parking applications have visibly boosted the day to day performance of the parking lot at Semen Gresik Hospital. Most visitors now report shorter search times, a development that relieves congestion both on the access roadway and within the facility itself. Smart parking technologies now deploy a mixture of sensors, wireless beacons, and centralized dashboards that inform drivers about open spaces the moment they pull onto a block. Research suggests that this immediate feedback trims hunt time by half, which in turn eases street congestion and cuts engine idle pollution [10] [29]. Closed garage experiments have paired ultrasonic beam arrays and camera image processing so that overhead lights point exactly to vacated stalls, a choreograph that minimizes the slow back-and-forth typical of compact facilities [29]. Paperless billing is usually woven into these schemes by flashing a scannable QR code at the exit, letting a phone quick pay the fare and glide away, a boon for hospitals where every saved minute matters [30]. Even though the initial hardware and install tab can make city budgets wince, savings on booth staff and upkeep mean the systems often break even within two or three budget cycles [23]. Cutting the loop driven search for stalls also shrinks fuel burn and CO2 puff, a finding echoed across trials from Europe to Asia [31] [32]. Cloud racks synchronize stall status with user phones in seconds, enabling pre-reservation that turns frantic parking hunts into casual drop-ins. Recent inquiries into smart-parking management illustrate how digital upgrades and the Internet of Things in particular make garages both financially sound and socially relevant [33] [34]. Such systems mesh neatly with larger smart-city agendas that seek to lighten traffic strains and polish the general quality of urban life [34]. A case in point may be the installation at Semen Gresik Hospital, where sensor networks and cloud interfaces cut search times, ease billing hassles, and leave most drivers in a noticeably better mood.

Digital technology now courses through modern parking management with a speed and capacity once confined to science fiction. Cloud dashboards hooked up to an array of street level sensors let drivers peek down a digital tunnel and spot vacant stalls before they even roll onto a block. Researchers tracking the shift note the change in tone-each open space discovered in an app carries the muffled sound of one less engine idling in frustration [35] [36] [29]. Wireless rubrics stitch together hardwired sensors, low-power beacons, and mobile funnels so that fresh occupancy numbers ping smartphones within seconds of a bumper leaving its mark [10] [37]. Some installations go a step further, lighting up arrows on the dashboard that follow the driver like eager geese, a tweak that drains fuel and temper alike [36] [15]. Yet even the slickest circuitry falls flat if the touchscreen layout demands more taps than a piano solo. An intuitive user interface usually ranks clarity, brevity, and uniformity at the top of its design checklist, if only to spare less tech-savvy groups-seniors, for instance the strain of guessing what each button does [38]. Even so, a fair number of customers still say the screens feel foreign, which dishes out a quiet reminder that hands on tutorials and community meet-ups remain vital for winning wider acceptance [38] [39]. Functions like live monitoring, instant reservations, and in-app billing deliver the sort of frictionless navigation that turns parking from a daily chore into a minor victory [1]. In the end, digital parking systems deliver real gains in rider comfort and fleet turnover, but those gains evaporate if interface kinks and thin user support are allowed to fester [35] [40] [41].

Recent advances in digital technology have reconfigured driverless-parking facilities. Automated billing, remote oversight, and user tutorials now work in concert to boost throughput and improve customer satisfaction. Automated payment schemes have emerged as a noteworthy advance in urban mobility. Multiple evaluations point out that they permit fully digital transactions, which cuts down on face to face encounters with parking attendants and frees up checkout lanes that typically choke during rush hours [30] [1]. The roll out of Internet of Things (IoT) gear has let drivers receive instant alerts whenever a space opens up nearby, thereby slashing the minutes spent circling in search of a lot [11] [36] [10]. Occupancy data flow from embedded sensors through wireless networks and land in smartphone apps or web dashboards, so users see live availability instead of stale estimates [36] [10]. Moreover, radio frequency identification (RFID) tags and automatic license-plate cameras are gradually taking over gate duties; vehicles glide in and out while human clerks watch from the sidelines, an arrangement that makes the whole system hum with improved speed [13] [42] [43]. Even so, many patrons hesitate until they grasp the software, so educational pop-ups, short videos, and in lot signage walk newcomers through the first few taps, easing the cultural shift toward these digitally reliant solutions [1]. The collective impact shows up where it matters: shorter queues, easier navigation to open stalls, and a noticeable drop in curbside gridlock, benefits that reverberate well beyond the dotted lines of a single parking lot. Maneuvering travelers toward the nearest vacant space cuts the time spent circling city blocks. A reduction in that circling yields two important payoffs. Less idling at the wheel conserves gasoline, and the smaller carbon footprint shows up as a direct environmental gain [36] [10].

Assessments of driverless parking apparatus reveal a striking reduction in both dwell time and vehicle backlog, a finding echoed across multiple inquiries into Internet of Things informed garages. By processing data in real time and operating largely on autopilot, these installations spare motorists the ceaseless hunt for an empty stall and, in

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doing so, help clear city streets of surplus traffic and cut down on carbon exhaust [11] [10]. The deployment of RFID, paired with cloud linked sensors, permits a hands free management regime that maximizes space yield while sidestepping most manual oversight [44] [15]. Still, engineers and designers must grapple with stubborn hiccups such as sensor misfires and the learning curve that unsettles first-time users. Technical glitches persist in smart-parking deployments, frequently interrupting system fluidity and highlighting the urgent need for durable sensor arrays alongside fail-safe communication protocols to relay real-time data without loss (Elashmawi et al., 2023; [1]. User comfort, meanwhile, hinges on more than hardware; an informed driver must grasp a redesigned interface that swiftly translates the leap from manual to automated parking controls [45]. Even so, the upside is alluring: shorter search times, diminished CO2 footprints, and perks such as instant payment processing plus in-app space alerts [46] [47]. Sustained progress is required to marry that promise with reliable infrastructure and approachable design, demanding engineers and behavioral scientists collaborate until both technology and people keep pace [48]. Ultimately, while unmanned parking software has repeatedly proven it can streamline vehicle flow, overcoming its persisting technical hiccups and easing public adaptation stand as the final hurdles to ideal performance.

The impact of digital technology on the unmanned parking system at Semen Gresik Hospital goes beyond daily efficiency and extends to issues of sustainability and managerial innovation. With sensor-based devices and mobile applications, the hospital has been able to double its vehicle capacity on land that was previously fragmented. The flow of vehicle arrivals and movements is calculated in seconds, so afternoon traffic jams are no longer a concern. The continuously collected electronic records provide hospital leaders with a data mirror to map peak visit times, schedule maintenance for entry lanes, and maintain the parking structure before it deteriorates. In the financial realm, passengers can now pay via digital wallets, while hospital treasurers only need to wait for balance reports to appear on their desktop screens. Although sensor programming and digital screens may seem straightforward, transforming all these devices into a seamless parking ecosystem within a hospital requires complex work behind the scenes. Security personnel must know how to read alerts, technicians must ensure cables and servers remain operational, and legal teams must continuously map out which health regulations are still in effect. Red-tape compliance is no room for experimentation, so unconventional learning routines and relentless maintenance must become second nature if the technology is to be truly reliable.

4. Conclusion

A recent study at Semen Gresik Hospital revealed that the implementation of a digital manless parking system has increased the operational capacity of the health institution, a finding in line with literature on the automation of public facilities. Automatic sensors, smartphone applications, and electronic payment interfaces collectively cut down the time spent searching for parking spaces, speed up transaction queues, and reduce queues at the exit gate. However, a number of obstacles remain, ranging from technical errors in sensor units to user uncertainty due to unfamiliarity with touch screens or QR codes. In other words, this innovation does increase limited parking space capacity, facilitates access for patients in a hurry, and supports the daily rhythm of the hospital. To ensure these benefits are not temporary, managers must strengthen infrastructure, conduct training sessions for visitors, and perform regular maintenance to ensure the system remains reliable in the years to come. Based on the results obtained, hospital managers should prioritise technical infrastructure upgrades. Regular maintenance of sensors and verification of hardware compatibility will ensure that the man-less parking system functions without obstacles. User education is also important; regular socialisation of the automatic payment mechanism and mobile application can reduce patients' awkwardness when using the facility for the first time. For ongoing research, a deeper analysis of the system's impact on hospital operational workflows and visitor satisfaction levels should be a key focus. A comparative study with similar institutions that have already implemented the same technology would further enrich the understanding of both the successes and challenges of digitalisation in a medical environment.

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