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The Journal of Information Science Theory and Practice (*JISTaP*) is an international journal that aims at publishing original studies, review papers and brief communications on information science theory and practice. The journal provides an international forum for practical as well as theoretical research in the interdisciplinary areas of information science, such as information processing and management, knowledge organization, scholarly communication and bibliometrics. JISTaP will be published quarterly, issued on the 30th of March, June, September, and December. JISTaP is indexed in the Scopus, Korea Science Citation Index (KSCI) and KoreaScience by the Korea Institute of Science and Technology Information (KISTI) as well as CrossRef. The full text of this journal is available on the website at http://www.jistap.org

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Media Dependency and Public Skepticism in Authoritarian States: Discursive Trends in Disseminating Information about COVID-19 in Iran

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ABSTRACT

Being one of the first and hardest hit countries by the coronavirus, Iran still continues to preserve its place among nations with the highest rates of infection and COVID-19 related deaths. While on the surface, such worrying status evinces the failure of the authorities in handling the crisis, at deeper levels, it points to the fundamentalist nature of the government and political system of the country. In this view, the current devastating condition in Iran is a clear indication of the all-out influence of the Islamic regime's ideologies on officials' decision-making and their political agendas throughout the pandemic. Accordingly, the state-run mainstream media, as the most preeminent institution of power, have been incessantly engaged in disseminating a series of ideology-laden information around the issues concerning the coronavirus, and in line with the developing political discourses during pandemic. Far from being based on factual accounts or scientific facts, these disseminated messages inevitably grew into a source of disinformation, ultimately resulting in overall public confusion and skepticism. Through examining the data gathered from some of the most prominent online news agencies run by the government, this study identifies five major discursive trends through which the mainstream media propagated ambiguous and manipulative information about COVID-19. These findings are then explained in the light of media system dependency theory, leading to the argument that within autocratic nation-states, public reliance on media during a national/global crisis brings about new opportunities for state exploitation, and further distressing consequences for the people.

Keywords: COVID-19, Iranian mainstream media, ideology, media system dependency

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1. INTRODUCTION

On 19 February 2020, the Ministry of Health in Iran announced the death of two patients with COVID-19 symptoms in the city of Qom. Only a few days later, Iran became a country, apart from China, with the highest number of coronavirus infections in the world (Barnes-Dacey et al., 2020). In fact, within a month and by the 20th of March, the official reports indicated a sharp increase in the spread of the disease with more than 19,644 cases of infection and 1,433 fatalities. Subsequently, in less than a year these numbers reached to 1.9 million infections and 63,000 deaths, while at the present time such figures exceed 6.1 million and 130,000, respectively (worldometers.info). Yet, according to some of the independent analysts as well as frontliners and eyewitnesses in the field, the actual numbers are indeed 3-5 times more than what is officially reported, suggesting the government's statistical cover-up (Fazeli, 2020b; Tajdin & Adamou, 2020). Simply by looking at these alarming figures as well as the lack of transparency in reporting them, what first and foremost becomes obvious is the government's apparent failure in handling the pandemic.

At a deeper level, however, the government's inability to curb the spread of the disease and decelerate the mortality rate, not to mention the economic downturn and social disorders, can be traced to the fundamentalist and authoritarian nature of Iran's political system (Parsa, 2020). This is not surprising, since the Islamic regime is already known as a political entity that has persistently used its religious and ideological fundamentalism to guide its rule over the nation and its international diplomacy throughout the past four decades or so (Ehteshami, 2017; Tajmazinani, 2018). Central to such ideological dominance, while operating within anti-West and Revolutionary doctrine, is the state-run national media (Talebian & Talebian, 2019). Accordingly, during the pandemic, the national media have been actively engaged in disseminating a series of ideology-laden information about the coronavirus, in tandem with the developing political discourses and in support of the ruling clerics.

This is indeed paradoxical, since the national media, from a normative perspective, are considered to work for the nation; they primarily exist to benefit people by providing them with useful and critical contents, especially at times of crises. Therefore, it is reasonable to think of national media as the main government-public communication channel which is traditionally considered to be the most effective means for informing and mobilizing the public against time to reduce the impact of a calamity. Yet within undemocratic nation-states such as Iran, this does not seem to be the case; these institutions of power are merely employed to solidify the state's legitimacy and justify or disguise its oppressions, giving precedence to elites' interests over the well-being of the people (Blout, 2023).

In this way, the disseminated messages by the Iranian mainstream media during the pandemic, rather than presenting factual accounts, scientific facts, or unbiased analyses, reflected the state's ideological principles and political ambitions. Therefore, the gradual accumulation of this ambiguous and manipulative information has inevitably led to overall public confusion and skepticism. In regard to such a disquietingly negative climate in Iran, Alimardani and Elswah (2020) have highlighted issues such as "lack of public trust in officials, religiously charged narratives by unofficial fringe figures and political manipulation of the discourse," as factors shaping the public attitude towards government. Similarly, other authors have pointed to the hindrances in awareness brought about by purveyors of politics and religiosity which have resulted in public cynicism (Blandenier et al., 2020). Moreover, a number of researchers have variously shown the public distrust in the healthcare system and other government sectors responsible for the fight against the pandemic (Larson, 2020; Vardanjani et al., 2020).

2. PURPOSE AND METHOD

The purpose of this study is to identify and look into some of the discursive trends in the Iranian mainstream media's dissemination of ambiguous and manipulative information about COVID-19 and the social/political issues around it. Using critical analysis, it chronologically examines a number of main news reports which appeared on some of the government's most prominent online news agencies in various junctures of the pandemic, reflecting on the Islamic regime's politics/ideologies behind such accounts. Lastly, the study's findings are further explicated in light of Media System Dependency (MSD) theory, providing some insights on how Iranians' reliance on the mainstream as well as alternative media during the pandemic has led to overall public confusion and skepticism.

Unlike most contemporary theories of society that follow the predictive science, the critical theory embraces the moral philosophy, since it is chiefly concerned with "evaluating the freedom, justice, and happiness of societies" (Ingram & Simon-Ingram, 1992, p. xx). Derived from this paradigm is the critical analysis that, according to the

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framework proposed by Nixon et al. (2017), may consist of seven steps: (1) naming the specific aspect of practice being analysed, (2) identifying the intended purposes of this aspect of practice, (3) uncovering the assumptions that support these intended purposes, (4) identifying who benefits, (5) identifying who is disadvantaged, (6) linking these specific ideas to society-level patterns, and (7) conceiving of alternatives that mitigate actual or potential harms.

As noted by these authors, being theoretically critical does not necessarily mean being negative. Rather, it suggests thinking deeply and carefully about the (un) intended consequences of the actions taken in a society. Nonetheless, the application of these steps in each of the subsections of Section 3, though not in a distinctly outlined manner, proceeds as follows: (1) pinpointing the spread of specific information about COVID-19 by the government, (2) identifying the government's intention in spreading such information, (3) revealing the possible reasons behind such action, (4) considering the interests sought by any faction of the government, (5) considering the harming consequences of such actions on the people, (6) reflecting on how the government's interests fit into its ideological position, and in regard to (7) the Conclusion section, discussing an overall courses of action that the government could or should take in preventing or minimizing harm to the Iranian people.

The evidence for this study, however, was gathered from a number of the online news agencies that are run or funded by the government (Table 1). Given that these news agencies function strictly within the Islamic Republic's media and mass communication guidelines, they are obliged to preserve the interests of the state, and therefore, their news reflects the state-run mainstream media's. This means that the selection and representation of the news across the state-controlled media outlets, regardless of their size, type, or nature, from subsidiary online news agencies to the Islamic Republic of Iran Broadcasting (IRIB), essentially follow the same protocols, as they are set to convey the same message in a more or less similar fashion (Khiabany, 2010). Therefore, deciding on a particular source of news over another, or the number of them, did not seem to have a bearing on critical analysis in terms of reinforcing the foundation of this study's claims, so long as they function under the state's control.

Table 1. Online news agencies and their affiliations to the government

Online news agency	Affiliation
Islamic Republic News Agency	The official news agency of the Islamic Republic of Iran (www.irna.ir)
IRIB News Agency	The online platform of the Islamic Republic of Iran Broadcasting (IRIB) (www.iribnews.ir)
Ensaf News	Ranked 4th by the Ministry of Culture and Islamic Guidance and partially funded by the government (www.ensafnews.com)
Mizan Online News Agency	Associated with Iranian judiciary (www.mizanonline.ir)
Mashregh News	Non-governmental news website, but linked to the Iranian security and intelligence organizations (www.mashreghnews.ir)
Fars News	The second most visited pro-government online news agency, directly supported by the president himself (www.farsnews.ir)
Iranian Students' News Agency	Funded by the government as well as the academic center for education, culture and research (www.isna.ir)
Tabnak	The most visited domestic news site that supports the conservatives, and prominently covering the news of this political faction (www.tabnak.ir)
Kayhan (online)	The most conservative Iranian newspaper published in Tehran, with its editor (Hossein Shariatmadari) being an official representative of the supreme leader (www.kayhan.ir)
Basij News	Established and operated by Basij, an auxiliary to the Islamic Revolutionary Guard Corps (www.basijnews.ir)

3. DISCURSIVE TRENDS IN DIFFUSION OF INFORMATION ABOUT COVID-19

3.1. Politics of the Initial Trivialization of the Crisis

On 7 February 2020, Tabnak Professional News Site published an article titled: "Corona virus and unreasonable panic in society," in which the author lamented "Dear compatriots, unfortunately the world's lobbyists of power [the West] are in an outright war with China, and this is evident in the unreasonable panic that they have created... the symptoms of infection by Corona are not more serious than the simple cold's... we still do not have a single positive case in Iran" (Tabnak, 2020). The next day, on 8 February 2020, only two days prior to the anniversary of the Islamic Revolution that is celebrated yearly since

1979, Islamic Republic News Agency (IRNA) published two end-to-end news articles with the headlines "No case of coronavirus has been seen in Qom" (Islamic Republic News Agency, 2020a) and "By attending the demonstration, the nation will show the greatness of the Islamic Republic to the world" (Islamic Republic News Agency, 2020b). As a matter of fact, just a few days before the publication of these bulletins, a number of healthcare personnel had reported the hospitalization of several patients with COVID-19 symptoms in Qom (the holy city near Tehran), two of which were by then announced dead (Kursun & Ahmed, 2020). The reports of the arrival of the coronavirus and the seriousness of its quick spread across the country, however, were largely suppressed by the authorities for at least three days before they unhurriedly began to admit these reports (Alavi, 2020).

Flagrantly, the plan to withhold news about the spread of the virus in Iran was contrived by the state for a number of reasons: Firstly, the anniversary of the Islamic Revolution, which each year draws large crowds to the streets, is of paramount importance for the ruling clerics in Iran since this ceremonial event is considered to be a form of public endorsement for the regime's legitimacy (Intini, 2015). Hence, it is reasonable that the authorities would stifle the healthcare providers' warnings about the outbreak of the virus at any cost, for fear of deterring the masses from attending the demonstration. Secondly, in a similar manner, this cover-up was designed to avoid affecting turnout at parliamentary elections, which were also a few days away, precisely because the arrival of fewer people at the polls would be translated as less popularity of the Islamic regime (Wintour, 2020). Thirdly, the holy city of Qom, where the coronavirus initially emerged in Iran, is home to some of the most prominent Shiite religious sites that draw thousands of pilgrims from around the world (Badshah et al., 2020). Thus, the city's lockdown would bring about a downturn in worshiping activities and thereof the clerics' revenues (Nhamo et al., 2020), not to mention people's loss of faith in the sacredness of the city, which was widely held by believers to be protected by the divinity (Wood, 2020). The authorities' precarious decision-makings about not considering any precautionary measures in Qom, therefore, provide a glimpse into the regime's economic ambitions and religious orientation, as well as its disregard for the life-threatening risks that such decisions might bring about.

Taking everything into account, the authorities' initial trivialization of the coronavirus clearly illustrated the state's absolute control over dissemination of information and mainstream news politics in Iran. More importantly, this incident took place at a critical point in time when expediting the diffusion of accurate and transparent information could substantially reduce the devastating effects of the pandemic. In this way, what motivated the state to take such drastic measures and cover up the presence of coronavirus infections in Qom also highlights a major theme in revolutionary doctrine, reflecting the ruling clerics' views on the unequal elite-masses power relations. Indeed, since the inception of the Islamic Republic, the interests of powerful groups have been given precedence over those with less power, quite the opposite to what was promised to the people of Iran by Ayatollah Khomeini, the founder of the Islamic Republic in 1979 (Gholizadeh & Hook, 2012).

3.2. Untimely Politicking for Iran's Superiority

On 15 April 2020, IRIB News agency published an article headlined "The high accuracy of the Corona detector" (IRIB News, 2020). Attached with a video clip showing the official ceremony, this article was about a counterfeit device named *Mostaan 110* being unveiled by a number of high-ranking generals headed by the Commander-in-Chief of the Islamic Republic Revolutionary Guard (IRRG) Hossein Salami, who claimed that their researchers' state-of-the-art invention can detect the coronavirus remotely within a 100 meters radius in less than five seconds. As part of his speech in this video clip, Salami asserted that IRRG's so-called 'technological feat' was a "hard punch at the mouths of the Islamic Republic's enemies," a catchphrase oft-repeated by Iranian officials and their sympathisers, indicating a confrontational move punishing the West. The sudden appearance of this unverifiable device, however, echoed loudly throughout the national media outlets, especially at a time when the whole world was in a search for ways of detection, prevention, or curing the illness caused by the deadly virus. Simultaneously, Iranian Students' News Agency reflected on this event under the title: "Major General Salami: *Mostaan 110* was invented by the Basijis" (Iranian Students' News Agency, 2020). Of course, to specifically include the word 'Basijis' in the title and giving them credit for their invention was already an indication of politicizing the case, as Basijis are paramilitia individuals who serve as an auxiliary force engaged in enforcing state control over society (Golkar, 2015). This cheap-looking device, however, was very soon debunked by several domestic and international scientific groups, most notably the Physics Society of Iran which called *Mostaan 110* "an unbelievable claim, as far as science fiction

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is concerned" (Sinaiee, 2020).

Another instance which exemplifies the state's political campaigning during the pandemic was reflected in various national press outlets, such as the article published on 20 February 2020 by IRNA. The title of this article was a quote from the Deputy Minister of Health, saying "Iran is ready to provide help for the United States in order to control Corona" (Islamic Republic News Agency, 2020c), which is clearly an absurd and sarcastic statement politically organised in line with the Islamic regime's other pretentious gestures of superiority over the West. The article then continued: "The US healthcare system is incapable of controlling the coronavirus," suggesting that Iran is in a better position than the US in regard to handling the pandemic.

What both of these articles show is the Islamic Republic's obvious determination to demonstrate Iran's upper hand in science and technology over the West, sending a message to its so-called 'enemies' about the state's self-sufficiency and its independence from major powers. Furthermore, hastily publicizing an unrealistic achievement, and only days later deceptively representing the US as destitute for Iran's help, right at the time when Iranians were desperate for international aid, was not only hypocritical but also once again provided strong evidence of the state's complete conviction to the Revolutionary principles.

3.3. Promoting a Sacred Formula for Curing COVID-19

As soon as the World Health Organization announced that Iran was one of the largest coronavirus epicentres in the world, any further hesitance by the authorities to admit the critical situation of the pandemic in Iran became too obvious to keep under wraps. As the officials' further suppression of information on the seriousness of the pandemic seemed to be outrageously perilous, a number of so-called 'Shiite medicine experts' sprang up and claimed to possess a sacred formula for preventing or curing COVID-19 (Arab-Zozani & Ghoddoosi-Nejad, 2021). Under the auspices of the Supreme Leader, who has always been a strong advocate of Islamic medicine (Khamene'I, 2023), various outlets of the national media started to back up these dubious and unscientific prescriptions. These ranged from encouraging people to purchase and consume a mysterious concoction named after 'Imam Kazem' to wearing 'Prophet's perfume,' an unknown scented liquid attributed to some other religious personage (Alijani, 2020). Despite the menaces of these alleged remedies, they were welcomed by the state media, and in several instances their advertisers were given space on national TV to hype their products, not to mention the Ministry of Health's lenient approach in evaluating the safety of such bogus mixtures. On 19 October 2020, for instance, Basij News published an article with a heading that read: "Do not miss taking Imam Kazim Medicine" (Basij News, 2020). In it, the author quoted Akram Fallah, an expert in traditional medicine who argued that the collection of the narratives of the prophet and his descendants contain about 6,000 pieces of medical advice that we can use today for treating Corona virus infection. Here, Fallah claimed that she had already treated seven patients who were severely infected by the virus.

Along with these incidents, there had also been some attempts by the Parliament to form the 'Islamic Iranian Medical Organization' and 'Complementary Medical Organization,' with more than 3,000 consultation offices for prescribing the so-called "Islamic Iranian Medicine," which immensely worried the scientific and medical associations in Iran (BBC News, 2021). The absurdity of such biased forbearance towards both the purveyors and advocates of Islamic medicine becomes more noticeable if one takes a look at the complexity of the bureaucratic structure involved in approval of the scientifically approved national and international medicines manufactured by some of the most well-established pharmaceutical companies (Abdoli, 2020). In this way, both locally made medicines and imported ones are required to undergo systematic scrutiny by policy and law makers as well as several institutions such as the Ministry of Health and Medical Education before being able to hit the market.

Such prejudiced acts are exemplified in an article published on 29 November 2020 by Ensaf News titled "The official position of the Ministry of Health on Imam Kazem medicine" (Ensaf News, 2020). This news article was published after massive controversies which rose up over the trustworthiness of the claims made by promoters of such religiously charged fake medicines, as their increasing number evidently resulted in expanding the rate of the spread of the virus and even more losses of life. As such, Ensaf News carefully took a middle stance and neither disapproved nor dismissed the usefulness of these manifestly ineffective and even hazardous products. In so doing, the article began by reminding the readers about the Supreme Leader's supportive views on traditional and Islamic medicines, before trying to explain that although there had been no approval from the Ministry of Health for Imam Kazem medicine, there was no solid evidence to prove its ineffectiveness. In response to this, for example, a video of a member of the clerical community was shown

on television and then was circulated in social media going room to room in a hospital rubbing the same bottle of the Prophet's perfume around the patients' faces while mumbling some Quranic verses. A few days later there were also some reports that the very same people who were given such treatments died from COVID-19, discrediting the claims made by their state-backed inventors (Fazeli, 2020a).

3.4. Western Vaccine: A Plot to Annihilate the Islamic Republic

On 8 January 2021, in a live televised speech, the Supreme Leader famously banned the import of the Western vaccines, especially those made by the US and UK, explaining that he had no trust in the West or their vaccines whatsoever (Rodziewicz, 2021). Expressing his lack of confidence in the West, and regarding their vaccine offerings as a plot to annihilate the Islamic Republic, he called himself the custodian of the Iranian people and hence responsible for their well-being. He further tried to ground his decree to ban the import of Western vaccines on the idea that if those vaccines were effective, there should not be so many COVID-19 casualties in the western countries, and that if their vaccines really worked, they should be unwilling to offer them to us.

Following Khamenei's controversial pronouncement, which caused massive criticism equally from inside the country as well as overseas, as usual the Iranian press began to back up his decision to ban the import of the Western countries' vaccines. In this regard, on 14 January 2021, Fars News reflected on the controversies and uploaded a news report with the heading: "The scientific reasons for banning the American and British vaccines" (Fars News, 2021). Quoting Payam Tabarsi, an infectious disease specialist who appeared as a guest doctor on national TV on a number of occasions, this report went on at great length about the numerous drawbacks of COVID-19 vaccines such as Pfizer and Moderna. Casting doubt on the safety of these vaccines, he maintained that in the production of their vaccines, Westerners do not take any responsibility whatsoever.

Similarly, and following the rising disputes about this contentious topic, on 19 January 2021, Mizan Online News Agency published an article with a headline that asked "Why are some quarters still insisting to import American and British Corona vaccines?" (Mizan Online News Agency, 2021). This article was in response to a number of Iranian health experts and medical practitioners who dared to express their worries over the rapidly increasing rate of COVID-19 cases in the country and the authorities' apparent failure to deal with the pandemic (Human Rights Watch, 2021). Trying to justify Khamenei's reasons for such decisions, the article went on to praise his sense of responsibility for the nation, defending his shrewdness in detecting and nullifying the enemies' sinister scheme to get rid of Muslims.

Elsewhere in the Mizan online news article there was an emphasis on the growing number of COVID-19 infections and deaths in Europe and America, as a way of substantiating Khamenei's reasons for suspecting the effectiveness of the Western vaccines. As such, the authors of the article deliberately chose not to mention the alarming situation in Iran, right at the moment when the clock was ticking for the authorities to avert a humanitarian catastrophe in the country. By the same token, and among other matters, the article overlooked the promising prospects of the high efficacy of the Western vaccines, missing the point that if such shots were developed with the sole purpose of slaying Muslims, then, obviously they would not be extensively used among non-Muslim populations (Khan et al., 2020). Nonetheless, along with the government's mismanagement in various areas, Khamenei's reckless fatwa to ban Western vaccines cost hundreds of thousands of lives. This could have been easily prevented by moving away from dogmatic views on Iran-West relations, and instead prioritizing the democratic and humanistic values involved in decision-makings at such high levels.

The forbidding of some of the most reliable and safe vaccines available in the world, therefore, brought to view just another case where the people of Iran were stripped of their lawful rights, as the Islamic regime once again proved that Revolutionary ideologies tip the balance against public health and human rights. Of equal importance, however, were the ways in which the national media, rather than being at the service of the people, tried to give their support to the ideological opinions of religious figures, facilitating the path for the fourth wave of the pandemic, which hit the nation in an unprecedented way.

3.5. The Fourth Wave: The Beginning of the Blame Game and Prevarication

In early April 2021, Iran entered the fourth wave of COVID-19, shortly after millions of people took their Nowruz (Persian New Year) holiday trips. In spite of the predictability of a nationwide coronavirus spread during the thirteen-day Nowruz holiday, however, the government did not come up with any practical extra measures or emergency plans beforehand to avert the crisis and

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curb the resurgence of COVID-19 cases and deaths. Instead, the officials' efforts in this regard were limited only to the issuance of a series of exhortations and warnings in television or press, or at best, randomly summoning traffic offenders without stopping them from continuing their journey. Unsurprisingly, just a few days after Nowruz when the fourth wave became evident, various political figures accountable for this colossal fiasco began getting into the blame game, or deliberately giving misleading and ambiguous explanations.

An example of this sort of scapegoating and prevarication appeared in a news story published in Mashregh News on 11 April 2021, headlined "The reaction of the press to the president's strange statements about the fourth wave of Corona" (Mashregh News, 2021). This article lashed into president Rouhani, who was the head of the National Coronavirus Combat Taskforce (NCCT), for pointing his finger at the Alpha (UK) variant of COVID-19, instead of taking responsibility for the fourth wave. The article argued that if the Alpha variant was the cause of the fourth wave, then as NCCT's head Rouhani was still at fault for allowing international flights during Nowruz to and from the countries known for being hot spots for this transmissible strain. The article went on to further criticize Rouhani for his earlier statements when he alternatively tried to blame the public for discounting health protocols such as unrestricted travelling as well as attending large gatherings and other social activities. Although the very same criticism was levelled at Rouhani by many other news agencies, *Kayhan* (the most conservative Iranian newspaper) used a more audacious tone in its online analytic news report titled "Government: In the new peak of Corona everyone is at blame, except us!" (Kayhan, 2021). Here, *Kayhan* called Rouhani a self-centred person who does not care about other people's lives but takes good care of his own: "He lifted the travel ban for the people, but he did not even agree to go to the parliament," and "he opened the schools but did not show up in the designated school to ring the bell to officially announce the beginning of the school year."

By closely looking into these articles alone, what becomes apparent is the turbulent and quarrelsome political climate in which various representatives from different administrations and interest groups confronted each other to whitewash themselves and weasel out of their responsibilities in regard to the rise of the fourth wave. Leaning on their positions of power and by using populist rhetoric, each party's involvement in this exchange of discourse was merely an effort to put the blame on their political rivals, or even the public itself, and to present their administration or interest group as faultless and scrupulous. The only exception here was the Supreme Leader and his close associates, who are considered to be untouchable elites. Obviously, reflecting on the tensions between various government divisions did not seem to reduce people's growing struggles, nor it instigated any effort to identify and bring to justice the individuals/groups responsible for the fourth wave of the pandemic. However, it marked just another juncture in which the Islamic regime proved its reluctance to pay attention to people's needs, while pursuing a ruthless agenda for maintaining the status quo to stay in power (Pollack, 2020).

4. MEDIA SYSTEM DEPENDENCY THEORY

MSD theory emerged to reformulate the question addressed by effects theory, by asking: "Under what societal and individual conditions do/don't media have substantial effects?" (Ball-Rokeach, 2015, p. 369). The theory's main premise is that the implications of a media system in the context of everydayness have effects at micro, meso, and macro levels, respectively impacting individuals, groups, and social systems, in the face of a threat or at times of uncertainty (Ball-Rokeach & DeFleur, 1976). Proposed for the first time by Ball-Rokeach and DeFleur in 1976, the theory suggests that people are likely to be influenced by media messages when they have little other experience or knowledge that enables them to verify or evaluate them. In other words, the extent to which audiences rely on a specific medium is a key variable in understanding why, when, and how media messages influence these individuals' beliefs, feelings, or behaviors (Littlejohn et al., 2016). Without a doubt, the observations of Ball-Rokeach and DeFleur have led to identifying some of the factors for the level of such dependency. One of these factors is how important a specific medium is to a person, group, or society for obtaining needed information. In this way, the more important these individuals or groups regard a medium for satisfying their needs, the more likely they are to depend on it, and be influenced by its messages. Another factor is the degree of social instability, which is more applicable for times of crisis such as national disaster, wars, political upheavals, and so on. In this sense, as the social instability increases, the more dependency of people on media for receiving information is predicted.

The 'media system' component of MSD theory, however, is best understood "as an information system whose powers vis-à-vis effects rest on the scarcity or exclusivity

of their information resources" (Ball-Rokeach, 2015, p. 369). Yet, as Ball-Rokeach pointed out, people might adapt or respond differently to the same social media environment. Furthermore, Jung (2017) explained that MSD is often misunderstood as an all-powerful media concept or the passive audience theory, simply for what the word 'dependency' might wrongly imply. Indeed, as he further put, the term refers to the possibility of an individual-media relationship that is "shaped by the degree of importance and helpfulness of resources one party possesses for the other party" (Jung, 2017, page 4). In addition, one's needs are not always strictly personal but may be shaped by the culture or by various social conditions (Baran & Davis, 2020). In advancing MSD theory, and from a macroscopic societal perspective, Ball-Rokeach (1985) hypothesised that as people's dependency on media grows more and more, institutions of media have no choice but to reorganise themselves to adapt to the upsurge of these dependencies. Accordingly, this is thought to result in the overall higher impact of media, therefore solidifying the central role of the media in the society.

5. DISCUSSION

This article began with making a case for the evident failure of the Iranian government in dealing with the COVID-19 crisis. It was then argued that disseminating a series of ambiguous and manipulative information about the coronavirus by the state-run national media has compounded the gravity of the pandemic and its devastating consequences across the nation. That is to say, the operations of the ideologically driven mainstream news media in Iran during the pandemic, rather than being mobilized for addressing the crisis and helping the Iranian people, were optimised for furthering the state's exploitative efforts. In line with this idea, a number of news stories, which throughout the pandemic appeared in some of the most prominent news agencies of the government, were critically analysed to exemplify the developing trends in diffusion of information about COVID-19, and to reveal their supporting ideologies. In this way, these analyses illustrated how the national media as a powerful means for government-public communication was deployed, not with the intention to address the needs of the people, but to take advantage of the developing narratives of COVID-19 to consolidate the state's domineering ideological position.

This is in fact typical among authoritarian countries where the mainstream media, just like other social institutions, constitute an imperative component of the ideological state apparatus, supplementing the functions of repressive forces within the boundaries of the nation-state (Althusser, 2006; Stier, 2015). The state's strong hold on media in this way is also explained by the contemporary propaganda theory which maintains that "public discourse is shaped and limited by powerful elites to serve their own ends" (Baran & Davis, 2020, p. 94). Moving further along these lines of thought, Semetko (2007) differentiated democratic countries from non-democratic ones and observed that the media-politics relationship in these countries varies depending on (1) how much media outlets are government funded, (2) the degree to which the media's content and reporting are free of government control, and finally (3) how much the parties, interest groups, and political participants have access to the media. In this way, just by looking at the media-politics relationship in Iran within Semetko's framework, one could imagine the degree of authoritarianism governing the country's political system: Institutions of media are owned or largely financed by the government while their contents are subject to maximum control and heavy censorship, not to mention the ruling clerics' exclusive power to influence the production and transmission of the messages (Mazrooei et al., 2019; Rahimi, 2015).

Having said this, besides identifying and analysing the discursive trends in broadcasting manipulative information within national media, this study also aimed to explicate the emergence and implications of these trends in the light of MSD theory. Looking at the interrelationships between the state, media, and public through this theory's prism, then, was thought to provide some insights into Iranians' dependency on media, as a way to understand the current public confusion and skepticism in the country.

Following this view, and to put it in perspective, it can be said that the long-term public dependency on mainstream media in Iran has been challenged by the emergence of new forms of media such as Internet and satellite TV since the early 1990s (Khiabani, 2015). This has evidently given a chance to the people of Iran to free themselves from the dominance of the national media, and to access an abundance of unrestricted media contents (Matin, 2023). Yet during the coronavirus pandemic there seemed to be a shift in this pattern, as the public moved towards national media and mainstream news, exactly because of their contents' tangibility for the people as well as their relevancy and applicability to the immediate contexts. That is to say, the contents of these state-run media

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outlets were apparently closer to people's real-life circumstances and their emergent needs for information, including updates on standard operation procedures and other instructions and guidelines issued by the government. The brief reconciliation between the people of Iran and the national media during the pandemic, however, turned out to be completely in accord with one of the main premises of MSD theory, which holds that there is an increase in people's dependence on media during social instability.

Unexpectedly though, the availability of new forms of cross-border media (mainly satellite TV and Internet) in Iran, and the growing influx of their unfettered contents, not only seemed to be incapable of counterbalancing the bias of the national media's messages during the pandemic, but also they appeared to exacerbate the challenges of the public in accessing trustworthy knowledge. There seem to be two main reasons for this: Firstly, the diffused information through new forms of transnational media (also referred to as alternative media) are in general inconsistent with those in the national media (Talebian & Talebian, 2018). The national-alternative dichotomy in media, therefore, seems to affect people in Iran, since these audiences are likely to oscillate between these oppositional news sources in search for reliable information, only to end up with a greater degree of uncertainty and confusion (Taghipour et al., 2023). This is in particular the case for those uncritical audiences with inadequate media literacy who become somehow intellectually paralysed when facing information overload or *infoxication* (de Bruin et al., 2021). Secondly, even though in general Iranians are highly suspicious of the accuracy and trustworthiness of the national media's reportage, they still tend to adhere to them simply because these have been the sole channels for people to obtain relevant and applicable information during the pandemic. Likewise, despite the pervasive use of social media in Iran, these digital communication platforms did not seem to be as constructive throughout the pandemic as they were during the Green Movement, a major historical uprising of Iranian dissidents in 2009 which shortly after sparked the Arab Spring in the Middle East (Tofangsazi, 2020). In other words, while social media were undoubtedly the catalyst for social mobilisation that successfully led to some of the recent years' most significant political changes in the region and around the world, their role in Iran and during the pandemic was arguably problematic.

What is more debatable, however, is that although Net-based communication channels are commonly known as powerful and beneficial means for crisis management, at least, this did not seem to be the case for Iran. In support of this argument, the results of several studies and reports have shown the counterproductivity of social media and other similar data sharing digital networks during the COVID-19 pandemic (e.g., Jafarinejad et al., 2021; Soltaninejad, 2020; Yoosefi et al., 2022). In fact, these accounts have pointed to a wide range of mis-/mal-/disinformation within these digital platforms (Sadati & Bagheri Lankarani, 2021), with the exception of a few that are associated with some well-known and reliable healthcare providers and medical professionals. Therefore, one could argue that although the emergence of satellite TV and the Internet has significantly improved the democratization process in Iran and many other countries around the world, especially during the past two decades or so (Comunello & Anzera, 2012; Tusa, 2013), they have evidently not been so helpful in taking pressure off people in their fight against COVID-19. Consequently, it can be said that while satellite TV and the Internet continues to attract the majority of Iranians who seek quality entertainment and unaltered news, it was the national media that during the pandemic turned out to be the main source of coronavirus related information for many people in Iran (Banakar et al., 2021). The resulting paradox of this is that despite people's increasing distrust towards the national media throughout the past few decades, during the pandemic they tended to deliberately ignore such doubts and at least follow the mainstream media's politically arranged news about COVID-19. By the same token, alternative media in Iran did not seem to live up to the normative and emancipatory expectations that are associated with these so-called counter-hegemonic forms of media.

Nevertheless, what all these insights point to is the significance of the interplay of social, political, and cultural contexts as well as spatial/temporal scope in understanding a particular communication phenomenon, especially if MSD theory is to be used as an analytical tool for research. The importance of context is also demonstrated by Loveless (2008), who studied media dependency in democratizing countries, and within the uses and gratifications framework. The focus of his study was on information-seeking behavior within "societies in states of crisis or instability" (Loveless, 2008, p. 162). Loveless (2008, p. 162) was primarily concerned with how citizens in countries undergoing a democratic transition sought information and assumed that there would be a "positive correlation between information-seeking and levels of media use". His findings suggested that the instability in countries which are in their embryonic stage of the

democratization process, and are undergoing a political shift, motivated people to seek more information through the media. Despite trusting the media's great capacity for providing information "to understand political transition," he cautioned that any interpretation in this regard should take into consideration the "historically and culturally differentiated media space" (Loveless, 2008, p. 178).

These findings point to the fact that understanding citizens' media dependency during national (or global) crises requires exclusive attention to "institutional and cultural variations" within each country, and in regard to specific local circumstances (Loveless, 2008, p. 178). This is, in particular, germane to any discussion of media dependency in Iran. On the one hand, the political system and social institutions of the country are driven by the state's unyielding ideological disposition, hindering the progression of the increasingly globalized and media saturated Iranian society. And on the other hand, the masses' increasing discontentment and disconnection with the government have given rise to an idiosyncratic form of the nation-state with its own distinctive cultural and political conditions (Golkar, 2020).

6. CONCLUSION AND IMPLICATIONS

While numerous studies in the past have addressed media dependency in democratic countries, there have only been limited efforts to link such theoretical perspectives to the social problems and complications facing the public within undemocratic contexts, particularly during a time of crisis (Khalifa & Khalifa, 2020). In response to this, the present study examined the national media's function in Iran, and Iranians' dependency on delivery of information through the state-controlled institutions of media. Here, the primary goal was to draw attention to the struggles of the Iranian people who were, more than ever, undergoing a great deal of hardship and despair, caused by a range of imprudent, unsympathetic, and outrageous actions/decisions made by the authorities during the pandemic. In so doing, the study's main focus was on the Islamic regime's ideological principles, considering them as the underlying basis for giving rise to the possibilities of new ways of exploitation. Under these circumstances, the interdependencies between officials, media, and society increase, and apparently the impacts of those interactions also become more noticeable.

Thus, this study recommends a robust and equitable collaboration and supervision at different levels and across various forms of media as key requirements for ensuring accuracy and avoiding distortion of data. Furthermore, as also noted by other authors (Arab-Zozani & Ghoddoosi-Nejad, 2021), the authorities in Iran should minimize bureaucracy and formalities for scientifically proven aids and methods, instead of relaxing such procedures for unscientific solutions and recommendations. Although it seems to be far-fetched, the government must feel the urgency to put people first and focus on providing reliable and consistent real-time data, instead of politicizing the crisis or seeking to project an unrealistically positive, popular, or powerful image of the Islamic Republic merely for meeting some political objective (Hen-Tov, 2006).

One more lesson to be learnt from the Iranian government's mishandling of the pandemic is that simply announcing some instruction or advice, and then expecting people to follow them, is doomed to fail. This means that while these regulations should be in place and communicated with the public effectively and early enough, the enforcement of such rules and guidelines as well as citizens' compliance with them should be monitored and confirmed on a regular basis. Lastly, giving precedence to religious or ideological beliefs over scientific measures, on the one hand, and abandoning responsibilities, making wrong decisions, and disregarding human rights and democratic values on the other hand, are all among the factors that have contributed to the deepening of the magnitude of the coronavirus pandemic in Iran. Thus, any improvement regarding public health, especially during national crises, seems to be possible only by taking the necessary steps to immobilize the ideological state apparatus which merely operates to keep the elites in power, albeit at the expense of the lives and well-being of its people.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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Digital Forensics Investigation Approaches in Mitigating Cybercrimes: A Review

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ABSTRACT

Cybercrime is a significant threat to Internet users, involving crimes committed using computers or computer networks. The landscape of cyberspace presents a complex terrain, making the task of tracing the origins of sensitive data a formidable and often elusive endeavor. However, tracing the source of sensitive data in online cyberspace is critically challenging, and detecting cyber-criminals on the other hand remains a time-consuming process, especially in social networks. Cyber-criminals target individuals for financial gain or to cause harm to their assets, resulting in the loss or theft of millions of user data over the past few decades. Forensic professionals play a vital role in conducting successful investigations and acquiring legally acceptable evidence admissible in court proceedings using modern techniques. This study aims to provide an overview of forensic investigation methods for extracting digital evidence from computer systems and mobile devices to combat persistent cybercrime. It also discusses current cybercrime issues and mitigation procedures.

Keywords: cybercrime, digital investigation, forensic investigation, mobile forensics, SM forensics, literature review

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1. INTRODUCTION

1.1. Research Background

In today's networked world, both cybercrime and cybersecurity are interconnected. The development of future IT trends depends on the security of existing networks and online services. It is imperative for the safety and economic development of all countries that cybersecurity measures be strengthened, and that critical infrastructure data be protected. The security of the Internet, and the protection of Internet users, have become an integral part of both the development of new services and the management of running services by governments and other business organizations (Ptaszynski et al., 2017).

According to Grover et al. (2016), national cybersecurity and critical infrastructure protection strategy places a strong emphasis on preventing cybercrime. These laws when enacted should be passed to prevent criminal acts or other issues of information and communication infrastructures, as well as acts that endanger the security of national key infrastructures. Cybersecurity presents global and far-reaching legal, technical, and institutional concerns that can only be met by a well-coordinated strategy that takes into account the roles of numerous players and current efforts while operating within an international framework (Edwards et al., 2018).

1.2. Cybercrime

A crime committed through a computer or computer network is referred to as a cybercrime. However, due to the rising frequency of these occurrences, handling and mitigating cybercrime incidents (CIs) has received considerable scientific interest in recent years. Similarly, the term *cybercrime* is frequently used interchangeably with other criminal activities connected to technology such as cyberterrorism and cyberwarfare, which causes complications (Nisioti et al., 2023). According to Morgan (2020) of Cybersecurity Ventures, worldwide cybercrime expenditures will rise by 15% per year over the next five years, reaching $10.5 trillion annually by 2025, up from $3 trillion in 2015. This is the largest transfer of economic wealth in history, threatening incentives for innovation and investment.

Moreover, this is increasing the number of disasters that cause harm in a year, which will be more profitable to criminals than the global trade in all major illegal drugs combined. Data damage and destruction, stolen money, loss of productivity, theft of intellectual property, theft of personal and financial data, embezzlement, fraud, and post-attack disruptions to normal corporate operations are among the most vulnerable problems caused by this threat (Hill & Swinhoe, 2022). In April 2019, it was revealed that two datasets from Facebook applications had been released to the public. More than 530 million Facebook account details were collected. This data was openly available two years later in April 2021, indicating considerable and actual criminal intent about the data (Pitchkites, 2022).

Data breaches can have devastating effects on hundreds of millions, if not billions, of people. The extent of data breaches has expanded in tandem with the rise of digital technology as cyber-criminals take advantage of people's increasing reliance on electronic information. One of the cyberattacks that knocked down the Yahoo server in 2016 was suspected to have been carried out by a hacker group. These hackers were reported to have gained access to the account information of more than a billion Yahoo users as the company was being acquired by Verizon (Hill & Swinhoe, 2022). However, about three billion Yahoo user accounts were compromised less than a year later. In 2020, the Internet Crime Complaint Center (IC3) of the FBI had its busiest year combating cybercrime, with a record number of Americans reporting being victims of cyberattacks. Since the beginning of 2020, the IC3 has witnessed a rise in phishing, spoofing, extortion, business email compromise attacks, and online fraud aimed at those displaced by the coronavirus pandemic (Pitchkites, 2022). In the same year, the IC3 of the FBI received 69% more cybercrime reports than in 2019. The global fight against the 2019 Coronavirus pandemic is continuing, while cybercrime abroad is growing exponentially (Interpol, 2020; Monteith et al., 2021).

1.3. Cybercrime Victimization of Businesses

Data breaches, distributed denial of service (DoS) attacks, phishing, and ransomware attacks are some of the threats that affects businesses who fall victim to cybercriminals. Research on the effects of ransomware and associated complications on data breaches has triggered serious problems, as noted by Agrafiotis et al. (2018). Certain characteristics, actions, and cybersecurity practices inside businesses are associated with a higher risk of being victimized and more severe repercussions (Connolly et al., 2020). However, a thorough knowledge of the fundamental tools and processes used to hunt down cyber-criminals is a crucial aspect of information security, for the simple reason that having expertise in these technologies makes the tasks of security professionals easier

and more efficient. Professionals in the security field may enhance their abilities to deter criminal behavior by acquainting themselves with and adapting to a variety of technology and tactics. Understanding these approaches may assist them in extending their perspectives as security professionals using their experiences while using technology across different domains (Baig et al., 2017; Horan & Saiedian, 2021). Similarly, despite these security measures, cybercriminals are always developing new strategies for executing cyberattacks. There are three separate layers of Internet crime, which consist of the "open" or "surface" online, the "deep" web, and the "dark" web. To prevent these criminal acts, investigators must be acquainted with the technologies and tactics that enable them to access and utilize the abundance of information accessible on different platforms including social networks. For instance, investigators may examine information on Bitcoin transactions on the dark web to gain insight into allegations of misconduct (Tymoshenko et al., 2022).

1.4. Research Purpose

The purpose of this study is to explore and analyse existing techniques for preventing and mitigating cybercrime from the researcher's point of view, particularly in the context of the current trend of IT services adoption. The Internet's simplicity, speed, and anonymity have created a new platform for criminals to expand their operations through cybercrime. The introduction of new advanced technologies such as social networks has resulted in cybercriminals implementing new patterns that are more mysterious and damaging to organizations and individuals. Cybercrime causes business owners to lose billions of dollars each year. However, it can take various forms, including financial crimes such as online fraud, abuse, computer attacks, and tolerance or encouragement of unlawful behavior such as gambling, child pornography, and copyright infringement.

1.5. Research Questions

i. What are the common approaches used by cybercriminals in launching their attacks?

ii. Why is cybercrime on the rise, and how can it be prevented?

iii. How prevalent is online crime? And how do forensic investigation techniques help in mitigating this menace?

1.6. Research Objectives

i. To examine and explore the approaches utilized by cybercriminals in carrying out their attacks to exploit individuals.

ii. To propose strategies for preventing cybercrime and implementing effective measures to adequately address it.

iii. To investigate the critical role played by forensic investigation techniques in mitigating cybercrimes.

2. RELATED LITERATURE

The field of cybersecurity known as "digital forensics" examines and recovers data from digital media to confirm or reject a security-related hypothesis. Evidence is carefully collected from digital media stored on digital devices (such as mobile phones and computers) that may have been utilized in criminal conduct (Flores et al., 2021). The significance of digital forensics for the use of digital evidence in the field of forensics science is projected to expand in the coming years. Sunde and Horsman (2021) reaffirm that both cybercriminals and security experts are using technology extensively due to its scalability. Consequently, the significance of cybersecurity and digital forensics cannot be overstated (Bankole et al., 2022). However, it is important to safeguard businesses from cyberattacks, benefit from digital pieces of evidence left behind after an intrusion or any cyberattacks, and be digitally andscientifically prepared for any kind of cyber/digital incident. According to Ariffin and Ahmad (2021), there is a plethora of studies on information security risk management models within the digital forensics domain.

Some forensic frameworks have already been developed for mitigating cybercrime in response to criminal acts committed in cyberspace. These models and frameworks have provided a fundamental base and starting point for further development during and after the forensic investigation process. The existing new framework has been used to refine the conventional framework. In 2001, Lee et al. (2001) presented a scientific crime scene investigation (SCSI) approach to digital forensic investigation. This paradigm provided a basic framework for digital forensic research in the domain. Although Lee et al. (2001)'s model was not developed in the field of digital forensics, it has had a considerable impact on digital forensics process models. In the same vein, Ciardhuáin (2004) criticizes the (SCSI) 2004 model for not providing a systematic digital forensics process, because his approach primarily focuses on physical crime scene investigation and misses some key essential organizational processes. Although Lee et al. (2001)'s criticism does not offer a solution, it does call for a thorough and methodical investigation. Though vari-

ous models have been developed and specified since 2014, none of these models involve a significant part of the cybercrime investigation.

However, Kohn et al. (2013) presented an integrated digital forensic process model that depicts the physical crime scene investigation approach and can be utilized for digital crime scene investigation. Several studies (Bankole et al., 2022; Dykstra & Sherman, 2013) in digital forensics examine hypothetical, experimental, and simulated security problems, which provides insights for investigation. Similarly, Weiss and Miller (2015), on the other hand, investigated a financial data breach at Target, a United State (US) based supply chain organization. Target lost around $248 million in 2013 as a result of fraudsters stealing financial details (the data breach was discovered in 2013). The Target financial breach report was made public as a consequence of payment system development legislation enacted by the 114th Congress. Adobe, Sony, Home Depot, and JPMorgan Chase are just a few of the many firms that have faced major digital forensics security issues, such as data breaches in which hackers obtained credit card information. Target and other companies have been obliged to retain third-party investigators to undertake digital forensics security incident investigations (Bankole et al., 2022). Most contemporary security approaches are reactive rather than proactive, and as a consequence they do not adequately address forensic and security concerns. Similarly, Spruit and Röling (2014) developed a model of information security maturity that classifies processes into four categories: technical, organizational, and technological, as well as support, organizational, and technical.

However, in a similar work Javed et al. (2022) conducted a comprehensive review of digital forensic techniques used in cybercrime investigations. They found that digital forensic experts employ different techniques such as digital evidence acquisition, data recovery, network forensics, and incident response planning. The authors also stress the importance of specialized skills and expertise for digital forensic experts to effectively combat cybercrimes.

On the other hand, Al-Khater et al. (2020) conducted a comprehensive review of cybercrime detection techniques with digital forensic techniques used in cybercrime investigation and prevention. They found that forensic experts use various techniques including digital evidence acquisition, data recovery, network forensics, and incident response planning. The authors also underscore the significance of collaboration and communication between forensic experts and other stakeholders, such as law enforcement agencies (LEAs), in effectively mitigating cybercrimes. In general, these studies provide valuable insights into the techniques used by forensic experts to mitigate cybercrimes, including digital evidence acquisition, analysis, interpretation, malware analysis, network traffic analysis, incident response planning, and data recovery (Kebande et al., 2020). Furthermore, the studies highlight the importance of continuous education and training for forensic experts, as well as collaboration and communication with other stakeholders to better combat cybercrimes (Javed et al., 2022).

3. CYBERSECURITY THREATS

Cybersecurity threats continue to grow in intensity, variety, and impact despite significant efforts by businesses, governments, and research institutes to address many of these vulnerabilities. Investigating current cybersecurity risks, evaluating the degree to which relevant protections have been implemented, and assessing the success of risk mitigation activities become logical as a result (Al-Khater et al., 2020). To properly address these concerns, extensive empirical data must be gathered and examined using a variety of Internet measuring approaches. Even though such measures may provide thorough and trustworthy insights, doing so involves difficult processes that call for the creation of cutting-edge approaches to guarantee accuracy and thoroughness. To illustrate how the Internet ecosystem was separated into many components, Pour et al. (2023) presented a taxonomy of cybersecurity focused as presented in Fig. 1.

There are several issues that arise from cyberattacks and a lack of cybersecurity concerns. In addition, many do not think cybersecurity is a major issue and hence rarely take precautions (Monteith et al., 2021). Therefore, the users and relevant stakeholders must have a greater understanding of the benefits of cybersecurity solutions. It is critical to protect the privacy of sensitive information stored on one's computer or a company's network. The data stored on computers or hard drives is both sensitive and confidential. In a corporate setting, this information might be used by competitors to bring a target down or perhaps wipe it out entirely. Disclosure of sensitive information might destroy a person financially in their private life. Information that is not meant to be shared publicly must be encrypted using advanced cybersecurity technologies (Al-Khater et al., 2020). Cyberattacks are difficult to manage, and implementing cybersecurity measures proactively reduces costs considerably. Attacks on cyberspace may result in the loss of clients and popularity for large

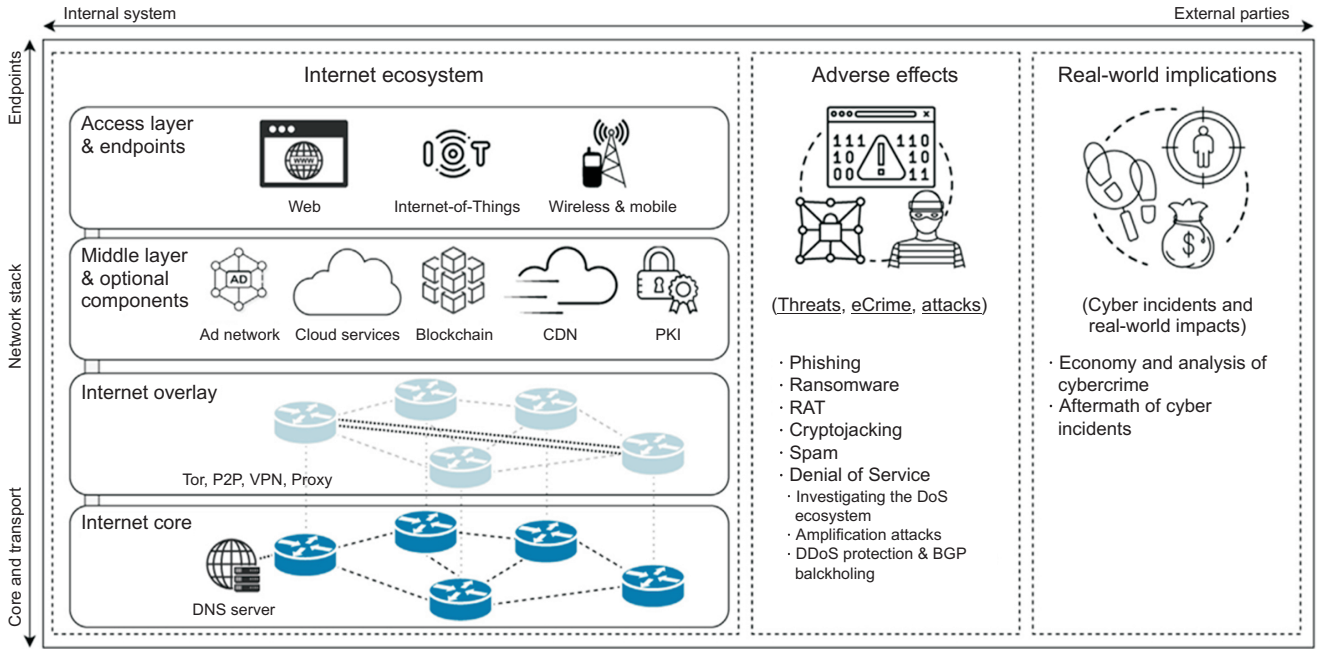


Fig. 1. The Internet ecosystem. Adapted from the article of Pour et al. (Computers & Security, 2023;128:103123). CDN, content delivery network; PKI, public key infrastructure; Tor, the onion router; P2P, peer to peer; VPN, virtual private network; DNS, domain name system; RAT, remote access trojans; DDoS, distributed denial of service; BGP, border gateway protocol.

corporations.

According to Morgan (2020), individuals are an integral part of the cyberspace ecosystem, and when they engage with a business, they may share personal information with the expectation of confidentiality. However, when cyberattacks occur and their information and data are compromised, it erodes customers' trust in the organization, which in turn has a detrimental impact on the company's reputation within the community. The perception of a company by the public plays a significant role in its success, and any damage to its image can result in the loss of customers. Therefore, in cybersecurity, as in other domains, it is better to focus on prevention rather than attempting to restore stability after a system breach. Safeguarding systems proactively is more advantageous than grappling with the aftermath of a malicious intrusion (Tsakalidis et al., 2019).

3.1. Cybersecurity Incidents

A cybersecurity incident refers to an attempt or actual breach of an organization's information security system and it can cause severe consequences for the organization, such as reputational damage and financial loss (Sultan, 2021). One instance of a cybersecurity incident is the Equifax data breach that occurred in 2017. Equifax, a major credit bureau in the United States, experienced a cyberattack that resulted in the exposure of personal data belonging to roughly 143 million individuals. The attackers exploited a flaw in Equifax's website software, which enabled them to obtain unauthorized access to sensitive information like social security numbers, birth dates, and addresses (Bernard et al., 2017). The incident inflicted financial loss and significant harm to Equifax's reputation. Another illustration of a cybersecurity incident is the 2020 SolarWinds supply chain attack. A group thought to be associated with the Russian government conducted the attack by exploiting vulnerability in the software of SolarWinds, a leading provider of network management software. The attackers manipulated the software's code to insert a backdoor, which allowed them to gain access to the systems of SolarWinds' customers, including multiple US government agencies (The White House, 2021). The attack had grave national security implications and led to increased scrutiny of supply chain security in the technology industry.

Generally, cybersecurity incidents are critical threats that can cause severe consequences for both individuals and organizations. The Equifax data breach and SolarWinds supply chain attack demonstrate how cyber-criminals can exploit software and system weaknesses to gain access to sensitive information. Therefore, organizations need to implement effective cybersecurity measures and

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regularly update their systems to prevent and mitigate the impact of cybersecurity incidents (Sultan, 2021).

According to Tsakalidis et al. (2019), CI Architecture provides a full cybercrime embodiment through feature identification, offense categorization processes, threat severity labeling, and a completely innovative Adaptive Reaction Policy (ARP) that identifies and connects the necessary stakeholders for preventative measures and response activities. The authors designed an architecture consisting of four unique, complementary components that result in a manually made ARP that will in the future be built automatically. The objective is to create a complete platform for the automated management of cybercrime. Fig. 1 depicts the proposed CI Architecture, which consists of four components (I, II, III, and IV). It provides a systematic approach to effective CI management with the objectives of generating insights and patterns about CIs, monitoring and evaluating the threat severity of CIs, and developing actionable and appropriate response policies and guidelines for organizations, individuals, and LEAs. The negative repercussions that these ideas could have in the actual world on various sorts of attacks are another instance. According to Tsakalidis et al. (2019), there has been a rise in the frequency of CIs in recent decades, and this trend is projected to continue. The economic impact of cybercrime has also increased in recent years and is expected to further rise by 2025. As a result, there is a pressing need for substantial enhancements in cybersecurity. In response to this, both national and international organizations have been implementing comprehensive techniques for managing cybersecurity incidents on a larger scale. This can be seen in Fig. 2, which illustrates the classification of these incidents.

3.2. Cybersecurity Challenges

Unfortunately, cyber-criminals have become proficient in turning their illicit activities into lucrative businesses. Sophisticated hacking tools, including those used in zero-day attacks, are readily available on the black market, allowing more people to pose a significant threat to the stability of networks and the overall cyber infrastructure. With the increasing reliance on mobile phones for daily tasks such as banking, office communication, and social media, the vulnerability of mobile networks to manipulation by hackers has also increased (Misra & Arumugam, 2022). This has led to a need for high levels of security, such as voice and facial recognition. The Internet of Things (IoT) has also become a significant target for hackers since they can control all devices through a single access point. Cybersecurity challenges are ongoing and continuously evolving, requiring equally evolving and updated countermeasures. Third-party sellers are also at risk of cyberattacks, which can be challenging to prevent due to the most protected areas being the employees themselves.

There is a significant gap between the level of preparedness and the type of cybersecurity issue at hand, with many businesses being aware of the risks but falling short in their responses. The increasing threat posed by cyber-criminals highlights the importance of taking proactive measures to prevent and mitigate cybersecurity breaches (Maalem Lahcen et al., 2020). Businesses must stay up-to-date with the latest cybersecurity technologies

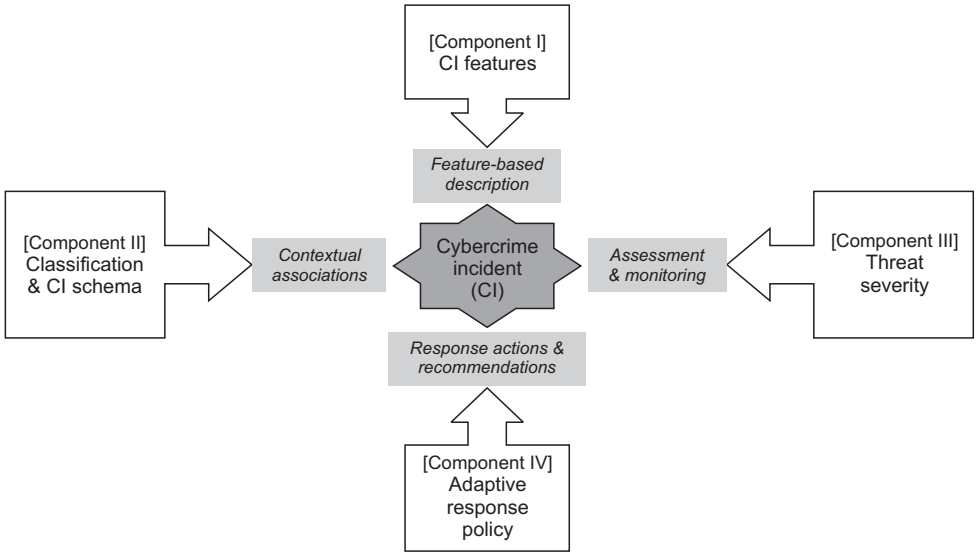


Fig. 2. An overview of the core elements of cybercrime incident architecture. Adapted from the article of Tsakalidis et al. (Computers & Security, 2019;83:22-37).

and techniques to ensure their networks and devices are protected from attacks. They must also take into account the human factor, such as employee training and awareness, to prevent human error from leading to security breaches. It is also crucial for businesses to collaborate with other stakeholders, such as government agencies and security experts, to share information and resources to combat cyber threats effectively. As technology continues to evolve, so do the methods of cyberattacks, and it is crucial to remain vigilant and adaptable in the face of evolving threats (Al-Khater et al., 2020).

4. DIFFERENT TYPES OF CRIMES COMMITTED

There is a wide variety of techniques that criminals use to trick their victims, especially those who have placed their faith in them. In many instances, forensic investigators are called upon to look into how cyber-criminals have used victims for malicious purposes (Al-khateeb et al., 2019). Collaborating with law enforcement and fellow forensic specialists, investigators in forensics strive to unravel the intricacies of a crime. The forensic team usually collects images or creates sketches of crime scenes to documents evidence, collects various forms of evidence such as fingerprints, bodily fluids, and human tissue. Moreover, this data collected can then be analysed in the laboratory. To identify the perpetrator of a crime, it is important to collect and analyse all pertinent physical evidence, which is the essence of forensic investigation (Nisioti et al., 2023).

Money laundering, theft, harassment, and child pornography are all common types of criminal conduct over the Internet (Yeboah-Ofori & Brimicombe, 2018). Online auction fraud, identity theft, financial and telecommunications fraud, credit card fraud, and many more crimes are examples of computer fraud. In the context of computer crime, theft crimes include monetary theft, service theft, data theft, and piracy, and most of these offenses end in allegations of cyber-stalking and cyber harassment (Sun et al., 2021). Child pornographic offenses, like other sexually related crimes, involve both the spread of innocuous material aimed at minors for sexual exploitation and the recruiting of teenagers to conduct sexual actions themselves. The following are some instances of the many types of illegal conduct that cyber-criminals often engage in.

4.1. Cyberstalking

Cyberstalking, in its broadest terms, refers to stalking performed with the use of a computer. Stalking is defined as "persistently harassing and threatening behavior, such as following a person, appearing at a person's house or place of business, making harassing phone calls, leaving notes or things, or vandalizing a person's property" (Arfaj et al., 2022). A cyberstalker is someone who pursues another person in this manner while using a computer. Stalking and harassment are defined as persistent communication via electronic methods (e-mail, instant messaging). In April of 2000, an extraordinary case of cyberstalking occurred in California. According to Nisioti et al. (2023), the defendant of the committed crime pled guilty in this case to charges that he attempted to solicit the rape of a female social acquaintance. However, one of the persons arrested, named Dellapenta, said in online personal advertisements and chat forums that the woman had always fantasized about being raped and played the victim. In his replies to the advertisements, he disclosed the woman's confidential information, including instructions on how to defeat her security system. Six of those who replied to her ad were aggressive and threatened to rape her if they had the chance, or threaten another person. Finally, the FBI and Sheriff worked together to catch Dellapenta. He was found guilty and condemned to jail for six years. However, there are other, less common types of cyberstalking (Dimitriadis et al., 2020). Because it is commonly aimed at persons who have not specifically requested it, spam or unsolicited electronic mail may also be considered a kind of cyberbullying.

4.2. Cyber Terrorism

Cyber terrorism is an illegal act that involves violence against individuals and properties, often driven by political, racial, or ideological motives (Al-Khater et al., 2020). This type of cybercrime often creates fear, anxiety, and violence among people and can also result in sabotage and destruction of properties, such as computers and networks, thereby affecting the availability and integrity of information (Lewis et al., 2017). The Internet is frequently used by terrorists to spread propaganda, recruit individuals, manipulate public opinion, and disrupt national infrastructure, including transportation, dams, traffic lights, and energy facilities. For instance, the Ukrainian attack on a power grid in December 2015, which was initiated with a phishing email, is an example of cyber terrorism (Al-Khater et al., 2020). Certain cyber-terrorist activities instil fear and disrupt citizens, which can also influence political decision-making. The adverse economic effects, property damage, and violence resulting from cyber terrorism can

result in fatalities and impact the unity of society (Internet Crime Complaint Center (IC3), 2020).

4.3. Cyberbullying

The increased usage of technology and social media among individuals of varying ages and genders has raised the likelihood of unwanted conduct, such as bullying. Bullying is a highly negative experience, especially during childhood, and is most commonly experienced by children, teenagers, and women. Bullying can cause emotional and mental distress and can impact an individual's character (Lewis et al., 2017). Victims of bullying may receive hostile and offensive tweets, messages, or posts that may include threats of violence or harassment (Nandhini & Sheeba, 2015). Cyberbullying is a form of cybercrime that encompasses activities aimed at causing harm to an individual, including but not limited to identity theft, credit card theft, bullying, stalking, and psychological manipulation (Arfaj et al., 2022). Table 1 outlines some of the different types of cyberbullying that victims may encounter. Table 1 outlines several cyber bullying types that a victim may experience.

4.4. Phishing Attacks

Phishing attacks are a type of online scam in which an attacker poses as a trustworthy entity, such as a bank or a social media platform, to trick a victim into giving up sensitive information like usernames, passwords, credit card numbers, or other personal data (Horan & Saiedian, 2021). Phishing attacks can be delivered via email, text messages, phone calls, or even social media messages. The messages may contain links to fake websites that look like legitimate ones but are designed to steal the victim's login credentials or other sensitive information (Al-Khater et al., 2020). Social engineering and online identity theft, also known as "phishing," occur when malicious actors create fraudulent websites to deceive users into divulging sensitive information. According to the Anti-Phishing Working Group (APWG), there were over 1.2 million unique phishing attempts documented in 2016 alone.

However, one common method employed in these attacks is domain squatting, particularly through typo squatting, where misspelled or slightly altered versions of popular domain names are registered with malicious intent. Another technique involves the use of Internationalized Domain Names (IDNs) to carry out homograph attacks, where visually similar characters from different languages are used to masquerade as well-known domains. The APWG defines phishing as a form of online identity theft that utilizes deceptive emails to redirect individuals to fake websites, tricking them into revealing personal or financial information such as credit card numbers, account credentials, and social security numbers (Nikkel, 2020). Victims may receive an email containing a link to a fraudulent website as part of the phishing scheme. Clicking on the link leads them to a website that appears to be a legitimate platform, like eBay, for example. Despite various mitigation efforts such as email filters, the removal of phishing websites, and the use of browser plugins to warn users about potentially harmful pages, the problem of phishing attacks remains a persistent challenge (Guo et al., 2021).

4.5. Ransomware Attacks

The motive behind widespread ransomware attacks is the expectation of receiving a ransom (Connolly et al., 2020). The objective of ransomware is to block victims' access to their data and demand a ransom payment in return for restoring access (Kolodenker et al., 2017). An end-to-end framework for analysing Bitcoin-based cy-

Table 1. Types of cybercrime

Different types of cybercrime	Nature of the crime usually committed
Cyber verbal abuse	The offender expresses their hatred towards the victim on the victim's social media account
Copying and cloning	The victim's social media profile, which comprises their personal details and photos, is hijacked and private information is acquired
Morphing	The offender retrieves the victim's photograph from their profile and utilizes it for pornographic intentions
Cyber libel	Also referred to as gossip, when the offender tries to disseminate false information about the victim on their social media profile or in online groups
Blackmailing	The offender unlawfully utilizes the victim's personal information obtained from their social media account. Women are particularly susceptible to blackmail and threats, which may include physical intimidation by enemies, ex-spouses, or stalkers

bercrime was developed by Ariffin and Ahmad (2021). From the point at which victims obtained Bitcoins to the point at which the operators cashed them out, the authors tracked all financial activities. The approach for forecasting future ransomware transactions within a ransomware family is novel, efficient, and manageable. The authors found that their method was more accurate than popular heuristic and machine learning (ML)-based approaches. Meanwhile, other authors have developed their methods for detecting ransomware, which led to the development of ground-breaking new techniques. Kolodenker et al. (2017) presented PayBreak as an automated proactive defensive strategy to counter ransomware. This strategy is predicated on the fact that hybrid encryption with symmetric session keys is used for safe file encryption on the target PC. However, the data was recovered from 12 of 20 distinct families of real-world ransomware in tests by PayBreak's authors. Similarly, one way to identify ransomware is by a graph-based technique, as proposed by Moussaileb et al. (2018). Over 700 unique ransomware variants were examined in this analysis of real-world threats. Exploring the file system on a thread-by-thread basis was shown to be enough for detecting malicious applications.

4.6. Online Child Pornography

The term "online child pornography" refers to the distribution of unlawful media involving and directed at adolescents, as well as the sexual exploitation of children by adults who utilize the Internet for this purpose (Akbari et al., 2022). The distribution or possession of child pornography is a federal violation under Title 18 of the United States Code (USC), sections 2252 and 2252A. Furthermore, as mentioned in 47 USC 223, it is prohibited to provide any kind of child pornography to a minor. According to the Business Software Alliance, the FBI's Cyber Crimes Program's Innocent Photos National Initiative is entrusted with investigating crimes like these on a national basis. In certain regions, the FBI collaborates with local law enforcement (Internet Crime Complaint Center (IC3), 2020).

5. DIGITAL FORENSICS

Digital forensics is a branch of forensic science that deals with the recovery and analysis of evidence from digital devices. The primary goal of digital forensics is to identify, recover, and analyse digital content to produce admissible evidence in a court of law (Hargreaves & Patterson, 2012). The use of digital technology has simplified criminal activities, making it easier for criminals to engage in unethical behavior such as tampering with evidence or documents. Digital forensics has emerged as a response to this evolution of crime, and the establishment of the Digital Forensic Research Workshop in 2001 marked the beginning of this field. Initially, the digital forensic investigation was defined as "the application of well-established and scientifically proven procedures for the gathering, identification, and validation of digital evidence that may lead to the reconstruction of criminal incidents" (Mohammad & Alqahtani, 2019). However, as with other scientific disciplines, digital forensics involves the development and testing of hypotheses and models to provide an investigative framework.

However, since its inception, digital forensics has made significant advancements and contributed to the progress of our society. Individuals and organizations are now well aware of the tremendous opportunities presented by this emerging field. With the continuous improvement of criminal methods in the digital realm, there is a growing need for standardized incident-response procedures to address the ever-increasing cyber threats and attacks. When examining digital forensic methods, one crucial aspect revolves around the collection of potential evidence, which serves as a vital artifact (Chuprat et al., 2018). Consequently, investigators involved in digital forensics must possess comprehensive knowledge and expertise in investigative techniques (Karie et al., 2016). Throughout the twentieth century, the popularity of digital forensics has grown significantly due to the widespread adoption and heavy reliance on technology. While traditional forensics defines evidence as physical objects such as blood, fingerprints, or hair that can be used to identify criminals, the concept of "digital evidence" encompasses anything that can be retrieved through digital devices and is associated with digital technology, such as digital files and data. The pivotal role in investigating digital crimes is played by the identification and collection of evidence from diverse sources. In the realm of digital forensics, any pertinent information crucial to criminal convictions is regarded as digital evidence, adhering to the principles of forensic science, and is stored and transmitted digitally as per the requirements (Khanafseh et al., 2019).

The field is also gaining traction with investigators, who have traditionally spent their time focusing on the development of distinctive models for use in digital forensics. Acquisition, identification, evaluation, and admission are the four main stages of the earliest proposed models for digital forensics. Different models have been presented

to illustrate the processes required in collecting and analysing information from a broad range of digital devices. According to Karie et al. (2016), digital forensics requires forensic analysts from LEAs to conduct thorough forensic analysis of digital evidence. However, the forensic examination of digital data is equally applicable to litigators and any other legal challenges associated with business organizations.

5.1. Digital Forensics Investigation

Digital forensic investigation is the process of collecting, analysing, and preserving electronic data as evidence in a legal case or investigation (Horsman, 2020). This type of investigation is typically used to identify and gather evidence related to cybercrimes, such as hacking, data breaches, intellectual property theft, and online fraud. The digital forensic investigation process involves several stages (Hemdan & Manjaiah, 2021).

a) Identification: Determine the scope of the investigation and identify the potential sources of digital evidence.

b) Preservation: Secure the digital evidence in a way that ensures its integrity and authenticity, preventing any alteration, deletion, or destruction of the evidence.

c) Collection: Collect the digital evidence using forensically sound techniques such as imaging the hard drives or copying the data from other devices.

d) Analysis: Analyse the digital evidence to identify relevant information, such as the nature of the cyberattack, the attacker's identity, and the extent of the damage caused.

e) Presentation: Present the findings of the investigation clearly and concisely that is admissible in a court of law.

Digital forensic investigations require specialized tools, techniques, and expertise to ensure that the evidence collected is reliable and admissible in court (Kohn et al., 2013). Therefore, it is important to involve experienced digital forensic investigators and legal professionals to ensure that the investigation is conducted properly, and the evidence is presented in a way that meets legal requirements (Marshall, 2021).

The term "digital forensic investigation," or DFI, refers to the process of gathering and analysing digital evidence such as data and files to establish facts for use in legal proceedings. Criminal investigations often include a postmortemexamination of digital evidence using forensic procedures.

Therefore, the results of these investigations might be considered by the court, since they were obtained through scientific procedures and techniques. Since electronic media is too fragile to physically inspect, a tool is normally employed to verify the integrity of the digital data (Hemdan & Manjaiah, 2021). To withstand judicial review, any digital forensic investigation must provide acceptable digital forensic evidence. In general, an investigation aims to discover more about a recent incident (Horsman, 2020). The primary purpose of establishing a potential root cause is to ensure that the investigation can withstand court scrutiny if the situation warrants it. Nevertheless, any investigation must be carried out with caution to guarantee that the investigator's conduct is such that the validity of the evidence supplied cannot be questioned (Marshall, 2021).

5.2. Prospective Digital Evidence

The concept of digital evidence as a distinct element with unique properties and characteristics based on functionality and origin was introduced by Carrier and Spafford (2004). While digital data possesses a physical form, it may not be immediately apparent in computer-based crimes, highlighting the significance of digital evidence for forensic investigators. A reliable framework that ensures the traceability of digital evidence plays a crucial role in detecting potential security incidents, identifying their sources, and understanding their history (Bennett & Diallo, 2018; Lutui, 2016). However, the admissibility, legality, and reliability of digital evidence can vary across countries and require careful examination.

During the examination of digital evidence, it is essential to adhere to fundamental forensic processes, including identification, preservation, acquisition, authentication, and analysis (Turnbull & Randhawa, 2015). Similarly, as the sources of digital evidence have expanded due to advancements in digital technology, investigators must establish reliable sources for each type of digital evidence collected during the investigation. Relying on inaccurate sources of digital evidence can be more detrimental than not using any sources at all, emphasizing the importance of employing scientifically proven methods when collecting potential digital evidence (Casino et al., 2021). However, it is crucial for any scientific procedures utilized in digital forensics to adhere to specific scientific principles and be based on measurable and scientifically established standards (Casino et al., 2021; Horsman, 2018; Javed et al., 2022).

5.3. Digital Evidence Traceability

Digital evidence traceability refers to the ability to track and document the chain of custody and the history of digital evidence, from its creation or acquisition to its presentation in court or other legal proceedings use (Al-Dhaqm et al., 2017). It is a critical component of digital forensics investigations and is essential to ensure the admissibility and reliability of digital evidence in court (Casey & Souvignet, 2020). The traceability of digital evidence requires meticulous documentation and record-keeping at each stage of the investigation, including the collection, preservation, analysis, and presentation of the evidence. This documentation should include the names and contact information of the individuals involved in each stage, the date and time of each activity, and a detailed description of the actions taken, and the tools and techniques used (Turnbull & Randhawa, 2015). Maintaining digital evidence traceability is particularly important in cases where the evidence may be challenged or contested, such as cases involving intellectual property theft, data breaches, or cybercrime. If the chain of custody and history of the evidence cannot be accurately documented and presented in court, the evidence may be deemed inadmissible or less credible, and the case may be compromised (Horsman, 2022).

However, to maintain digital evidence traceability, it is important to follow established protocols and guidelines for digital forensic investigations, including those issued by professional organizations such as the International Association of Computer Investigative Specialists, the National Institute of Standards and Technology (NIST), and the Scientific Working Group on Digital Evidence. These guidelines provide best practices for collecting, preserving, analysing, and presenting digital evidence, including recommendations for documentation and record-keeping to ensure the traceability of evidence throughout the investigation. In today's society, the traceability process has become a crucial component of many aspects of our life, including the digital investigative process.

This is confirmed by Karie et al. (2016), who believedthat traceability may identify occurrences of an event from several sources, assisting in the collection of evidence to be used in a court of law or for any other investigative purposes. The primary purpose of evidence traceability is generally to uncover potential digital evidence and link meaningful connections between the evidence that has been located. Given the origin of an artifact, traceability allows for the tracking of a chain of events as well as the prediction of process outcomes (Casino et al., 2021). As a result, investigators and LEAs may track all components of digital evidence based on its origin and history. The following table shows the evidence traceability guidelines (Table 2).

6. BASIC CHALLENGES IN THE DIGITAL FORENSIC INVESTIGATION PROCESS

There are a variety of difficulties in digital forensics that make it challenging to perform investigations; these obstacles can be categorized as follows.

a) Because digital forensics relies so heavily on evidence obtained from a different variety of digital devices (including laptops, tablets, servers, and cameras), the fact that each of these devices uses a unique data format may cause a significant challenge during processing and analysis.

b) The effectiveness of modern digital forensics tools: While the majority of digital forensics tools were designed to identify a specific piece of evidence, they can also be used for other purposes, like standardizing evidence formats, compressing collected evidence, and extracting crucial information.

Table 2. Evidence traceability

Direct evidence	Circumstantial evidence/ indirect evidence
Physical evidence/real evidence	Scientific evidence
Computer/laptops	Fingerprint identification
Mobile phones	DNA matching
Tablets	Hair and fibre comparison
Modems	Voice identification
iPads	DNA testing
Documentary evidence	Computer generated evidence
Photographs	Output on the monitor (visual)
Letters	Film recorder
Video	Evidence printed on printer
Audio	Evidence printed on plotter
Surveillance tapes	Visual output on the monitor
Printed documents	Charts
Empirical evidence	Criminal confessions
Temperature	Counterfeit money
Checks	Threatening letters

c) The expansion of digital technology in daily life has resulted in a tremendous increase in the volume of data collected from these devices. This enormous amount of data complicates various elements of digital forensic investigations, including the phases of evidence analysis and examination.

d) The format of data obtained from various digital devices necessitates the application of complex data reduction and evaluation techniques.

e) The challenge of building a coherent timeline from many digital sources may involve different time zones, interpret timestamps differently, or suffer from clock skew/drift, among other syntactical discrepancies.

f) One of the primary challenges in digital forensics is a lack of experience and resources, which is why investigators must personally verify the necessity of a specific instrument at various stages of an investigation.

7. DIFFERENT SUB-DOMAINS OF DIGITAL FORENSICS

Digital forensics encompasses several sub-domains that specialize in different areas of investigating and analysing digital evidence. These sub-domains include computer forensics, network forensics, mobile device forensics, memory forensics, forensic data analysis, multimedia forensics, incident response, malware analysis, cloud forensics, and IoT forensics. Each sub-domain focuses on specific aspects such as computer systems, network traffic, mobile devices, memory analysis, data analysis, multimedia files, incident response, malware, cloud environments, and IoT devices. These sub-domains often overlap, and a comprehensive investigation may require expertise from multiple areas. Investigations into crimes that include the use of a digital device as either a tool in the commission of the crime or as a target of the crime is carried out with the help of digital forensics (Choo & Dehghantanha, 2017). As shown in Fig. 3, the field of digital forensics is divided into several subfields.

7.1. Computer Forensics

Digital forensics, or computer forensics, is the application of legal and computer science principles to computer resources to determine the state of a digital artifact, such as a computer system or digital records and other associated information that might assist in the ongoing investigation (Freiling & Schwittay, 2007). To discover evidence of a crime, computer forensics experts investigate digital artifacts such as the data stored on computers and other

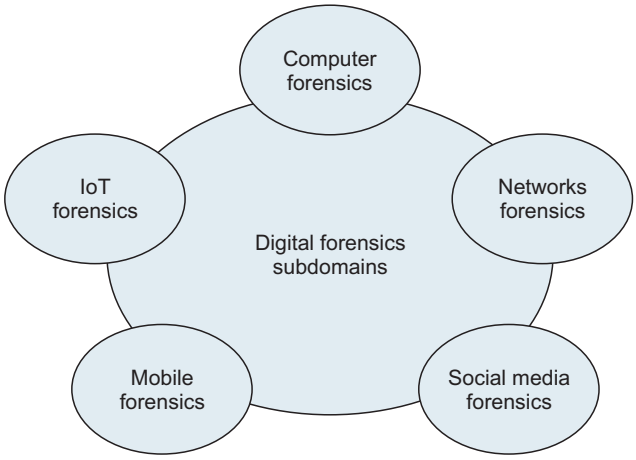


Fig. 3. Digital forensics branches. IoT, Internet of Things.

electronic devices. The time-sensitive nature of digital data means that it must be extracted quickly (Black et al., 2015; Javed et al., 2022). Since the late 1980s, there have been significant advances in the investigation of computer-related crime. Alongside scientific advances, developments in legislation, computer crime classification systems, and digital forensics methodology and theory have been enhanced and shown to be successful. Since digital forensics is still an emerging field, more study and development are required. Even while digital investigative software is rigorously tested to guarantee it is error-free, mistakes can still happen and result in overlooked or misinterpreted evidence.

Digital investigators need to know how to validate their findings to make sure they are correct, and they also need to know which tools are best for a certain task (National Institute of Standards and Technology, 2019). To validate a tool, it must be compared to another tool and its results recorded. This can be done to confirm that the two tools produce consistent results or to guarantee that one instrument correctly understood low-level data. For instance, all tools should reliably derive date-time stamps, and two programs should be able to recover the same deleted data from the same file system. Computer Forensic Tool Testing is a program run by the NIST that can help forensic investigators check the quality of their work and the reliability of their tools (NIST) (Kumar Raju et al., 2016). Forensic tools' ability to acquire digital evidence from storage media and retrieve deleted information is being actively evaluated as part of this endeavor. When performing these tests, we are not attempting to retrieve deleted data using superior gear. By using "spin stand testers," or hard drive testing equipment, some forensic labs can retrieve data

that was only partially destroyed (Holt & Bossler, 2015). With this innovation, operators can instruct the read head to retrieve information from the outer portions of a track that has not been overwritten by more recent data recorded in the track's center.

7.2. Network Forensics

Network forensics is a subfield of digital forensics that focuses on detecting and preventing cyberattacks on networks through the analysis and monitoring of network traffic. Network forensics analysis tools may provide services such as network forensics and security investigation, data integrity from many sources, target prediction for future attacks, network traffic analysis, and recording different forms of traffic analysis based on user demands. Here are a few examples of how the network forensics technique may be implemented at various network levels (McCullough et al., 2021). Sniffing tools, also known as monitoring tools, may be used to eavesdrop on bit streams at the Ethernet layer in network forensics, allowing the network forensics process to be completed at this level. Wireshark and the tcpdump are well-known tools for this purpose; tcpdump is especially beneficial for Unix-based computers and can help the investigator collect a variety of evidence at the Ethernet layer.

Internet Protocol (IP) is responsible for transferring transmission control protocol-generated packets across the network by attaching the addresses of their corresponding source and destination nodes (Choo et al., 2017). Every packet traveling from a source node to a sink node must traverse a sequence of routers, each of which maintains a routing table. In network forensics, one type of evidence is the routing tables, which can be used to track the origin of a packet to a specific machine (Javed et al., 2022). When addressing network forensics, the term "additional evidentiary resources" typically refers to the logs maintained by network devices that include information about network activities. Various network device logs can be correlated to reconstruct what transpired during an attack. Due to their limited memory, network devices can be configured to transfer logs to a central server for storage (National Institute of Standards and Technology, 2019).

7.3. IoT Forensics

The use of IoT technologies has recently increased significantly. Smart gadgets are employed in almost every major domain, including healthcare, transportation, smart homes, smart cities, and others (Kebande & Ray, 2016; Nik Zulkipli et al., 2017). However, this technology has several flaws that could lead to cybercrime via the devices. An alternative approach to investigation is required when dealing with crimes using IoT devices because of their alarming frequency (Awasthi et al., 2018). The amount of CIs employing this technology is anticipated to increase, according to Symantec's Internet Security Threat Report 2016.

There is evidence that fraud, ransomware, malicious attacks, node manipulation, phishing, and Structured Querry Language injections are committed utilizing IoT devices and applications, or that devices are used to perpetrate these crimes. Static digital forensics is far more difficult to undertake than conventional computer forensics on these devices because of their network connectivity (Oriwoh et al., 2013; Zawoad & Hasan, 2015). In addition, IoT forensics necessitates real-time investigation because of the limitations of IoT devices and the characteristics of digital evidence that demand proper management (Oriwoh et al., 2013). Fig. 4 depicts the many functions of the IoT environment and their interdependence.

These modules are supported by different processes including storage and timers which display the whole IoT system and how various entities are linked.

i. Sensor Module. Local environmental conditions may be detected and responded to by IoT entities. Sensing modules are classified into two types: controlled sensing and event-driven sensing. The first types detect only when the user or other sensors request the sensor's data at any point during execution (Nik Zulkipli et al., 2017). The latter is called event-driven sensing, and it occurs when

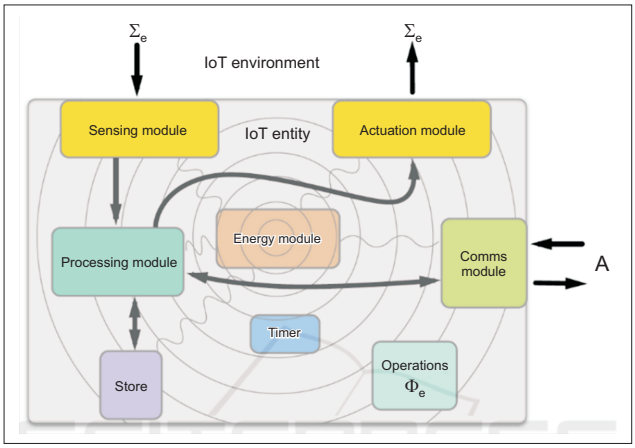


Fig. 4. Internet of Things (IoT) environment operations. A, actuators.

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the sensor senses change in its surroundings. The major function of this sensor is to collect and transmit data (or maybe both). The data is subsequently sent to the processing module, which processes it for the next phase. Each sensor in the IoT system requires a unique identifier and physical location to be identified and communicated with.

ii. The Module for Processing. This module is the IoT system's heart, serving as the local brain for the whole system of sensors and applications. The major function is to evaluate and transmit sensor data and information (Nik Zulkipli et al., 2017). Furthermore, by utilizing an application software command-control system, this module may be readily maintained and monitored. Data encryption and decryption are used in processing to safeguard communication. It is not, however, a ready-made device, and this module must be developed individually for the application.

iii. The Actuation Module. This module is in charge of turning on physical equipment and transmitting conditions to IoT entities through the environment. The processed data (also known as the result) will trigger the actuator to execute the result after the raw data has been processed by the processing module. In this module, there is no communication data or computer activity (Chourabi et al., 2012).

iv. The Communication Module. This component is required by all network systems. IoT devices, like any other sort of communication, have an IP address and a location. Because it is a critical module, data or results may be sent from the processing module to the network environment, such as a local area network or a wide area network. Because it links to or from the channel of communication between application software and local devices, the network connection is always in duplex mode (Nik Zulkipli et al., 2017).

v. The Energy Component. The amount of energy available for each IoT component has constrained the energy consumption of IoT devices (Nik Zulkipli et al., 2017). Each action requires a certain amount of energy, since each step from sensing through actuation, transmission, processing, and storage uses energy (Chourabi et al., 2012).

7.4. Mobile Forensics

Mobile device forensics, also known as MF, is a rapidly expanding field that encompasses a range of disciplines and focuses on extracting digital evidence from mobile devices for use in forensic investigations (Fernando, 2021; Zareen & Baig, 2010). In recent years, the majority of studies on mobile device platforms, data acquisition methods, and data extraction techniques have been carried out (Barmpatsalou et al., 2013). Researchers have extensively examined mobile apps to determine where and how private information is accessed. Choi et al. (2019), for example, analysed the database files of three popular Windows IM programs (KakaoTalk, NateOn, and QQ Messenger) to determine how the apps saved and encrypted their data and whether the databases could be decrypted without the mobile user's password.

Digital forensics, especially in the context of cybercrime investigations, has become increasingly dependent on digital evidence as society becomes more digitally advanced and incorporates technologies such as smart cities, smart buildings, and Industry 4.0. Surveillance cameras, IoT devices, and mobile devices are some examples of potential evidence sources in investigations such as drug or sex trafficking investigations (Zhang et al., 2021). Live memory forensics is a computer forensic technique that involves extracting temporary information from Random Access Memory, which remains effective even if the mobile device is turned off.

However, when conducting mobile forensics, it is common practice to examine both the subscriber identification module card and the phone's internal storage (Sharma et al., 2020). However, in another approach van Zandwijk and Boztas (2019) investigated data from the most popular health app on the iPhone 6, iPhone 7, and iPhone 8. They were able to properly determine the user's walking lengths, walking style, and walking speed using this data, giving a digital footprint that might be used as digital evidence. However, there are numerous unanswered questions and challenges in mobile device and app forensics. This is due, at least in part, to the fast development of mobile devices and apps, as well as the proliferation of available mobile devices during the previous decade. In their different literature analyses on mobile devices and app forensics, both Barmpatsalou et al. (2019) and Manral et al. (2020) recognized that data acquisition from mobile devices remained a major operational and research concern.

The challenge highlighted by Servida and Casey (2019) is evident in the utilization of encryption techniques for data-at-rest and data-in-transit, as well as in dealing with newer devices like IoT devices that lack support from existing commercial solutions. Investigating users' encrypted backup data on mobile devices is also deemed critical, as emphasized by Park et al. (2019). In their study, they examined the KoBackup and HiSuite applications, which are associated with Huawei smartphones, to illustrate how

forensic investigators can decrypt encrypted backup data and gain access to sensitive user information.

7.5. Social Media Forensics

Social media evidence is now at the forefront of both conventional and cyber-criminal prosecutions. However, this presents digital forensics with distinct legal and technological challenges (Basumatary & Kalita, 2022). Traditional techniques for the extraction and preservation of forensic evidence are inappropriate for social media forensics. Social media evidence is not self-authenticating; thus, further circumstantial and corroboration evidence is required for authenticity. However, the technological challenges are typically a result of the complexity and diversity of information stored on networks, and the legal issues involve the admissibility of evidence and data collection issues (Arshad et al., 2018).

The majority of social media research has focused on the extraction of data artifacts from devices and online social networks. In addition, integrating and correlating social media data to get insights into a crime is a challenge. In a recent study by Tommasel and Godoy (2019), in a single investigation, often hundreds or even thousands of diverse bits of information are forensically acquired for examination since the data is typically utilized to establish a connection between the suspects, the crime, and the victim. The process of correlating the data is often quite complex and might cause investigators or detectives to experience information overload. Furthermore, the information may not make much sense or benefit the investigation until investigators can manage the data into a unified and coherent representation (Nivedha & Sairam, 2015). Therefore, consistent data representation is vital for efficiently eliminating irrelevant data and gaining useful information and insight. Nevertheless, existing methodologies and tools within the domain do not provide these capabilities.

8. TECHNIQUES AND TOOLS USED TO ACQUIRE DIGITAL EVIDENCE

The most frequently used methods and tools for detecting and cracking down on cyber-criminals include digital investigation with forensics approaches that make use of open-source information. There is a variety of resources and techniques within these domains that may be used to collect information about a malicious attacker (Misra & Arumugam, 2022). This data might be used to build a case against the criminals and track them down. Digital forensics experts are frequently called upon to assist in the combatting of cybercrime by collecting and analysing the data that can be used as evidence in court proceedings (Jalali et al., 2019).

Digital forensics is a method used by law enforcement to investigate crimes by integrating digital evidence to determine what happened. Memory/disk analysis and network forensics are some ofthe components used in forensic investigation. By analysing data gathered from computers and networks, the investigation team may be able to pinpoint additional conspirators (Casino et al., 2021). This might help law enforcement to identify and bring these perpetrators to justice before they can commit more acts of violence.

8.1. Data Collection

The process of identifying, acquiring, and securing electronic data for use as evidence in a civil or criminal legal proceeding is known as digital forensic acquisition (Arshad et al., 2019). Although following the formal acquisition procedure and following legal standards is required for utilizing this information as evidence in court, this process is mainly performed by a person with sufficient skills in legal and technical aspects to assure legally sound acquisition (Karie & Karume, 2017). On social media, forensic artifacts are acknowledged as an important source of evidence. As a result, the majority of research efforts are focused on acquiring forensic evidence. The first research on social media forensic extraction focused on device-specific identification and recovery of traces left on devices by social network applications and web browsers. Typically, the requirements for forensic collection from social networks consists of obtaining pertinent data or content from diverse social media platforms, collecting metadata for social media content, and ensuring data integrity throughout the forensic collection process. (Khanafseh et al., 2019).

8.2. Timeline and Data Analysis Techniques

Several studies (Dadvar et al., 2013; Nandhini & Sheeba, 2015) have presented research on crime detection on social media to automate the identification of cybercrime, such as research on crime detection on social media published in several papers, to automate the identification of cybercrime.

Similarly, a keyword-based strategy for detecting cyberbullying has reportedly been presented by Hon and Varathan (2015) for effective detection of cyber-bullies. A similar approach (Chatzakou et al., 2017) proposes

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natural language processing (NLP) techniques combined with user behavior and their activities to identify hostile and harassing behaviors. According to Dani et al. (2017), sentiment analysis was employed to identify cyberbullying on social media. Similarly, there are just a few approaches to identifying malware and cyberbullying (Arshad et al., 2019; Dadvar et al., 2013; Nandhini & Sheeba, 2015).

These authors present an approach for detecting cyberbullying on Twitter based on keyword searches (Hon & Varathan, 2015). Similarly, some techniques are devoted to tracking illegal activity and criminal tendencies on social networks such as Facebook and Twitter (Alami & Elbeqqali, 2015). The evidence collection and analysis of online social media content is very crucial because multitenancy and virtualized environments create a serious challenge. However, cyber-criminals take this advantage in launching their attacks (Arshad et al., 2019; Kazaure et al., 2019). Although the social media data is sorted in chronological order, manual examination is not viable to uncover this diverse evidence. A typical chronology may include information over many years, including thousands of actions that are irrelevant to the current investigation.

Consequently, it is vital to develop ways for efficiently detecting cyber-criminals and find a suitable approach that can help to easily identify pertinent data, so that sensitive information that can reveal important findings after the investigation can be realized (Park et al., 2018). On the hand, NLP methods and data mining approaches are appropriate for the automated identification of illegal activities and cybersecurity analysis. They are, nevertheless, unsuitable for forensic investigation and legal presentation for two primary reasons. Initially, legal presentation necessitates the explanation of the logical process used to reach the outcomes of the data mining techniques used (Rossy & Ribaux, 2020).

However, it is challenging to explain the sequence of events that led to the evidence acquired during preprocessing and normalization phases of these approaches, since data provenance may likely be lost. Therefore, it is not possible to link the outcome to the source data (Han, 2016). Second, NLP and data mining approaches rely heavily on data processing techniques based on clustering and probability, which enable rapid identification of illegal conduct with high false positive rates. In automated detection systems, false positives are accepted as a necessary evil, yet they are unacceptable in court rulings (Du et al., 2017). Because real-world data is scarce in cybersecurity research, integrating rigorous analytical procedures with passive and active measurement techniques may provide information on a subject's security posture. Protocols, devices, apps, technologies, platforms, users, and threats are also rapidly expanding on the Internet. Meanwhile, in response to the increasing concern for users' and other organizations' privacy in cyberspace, numerous countermeasures to avoid information breaches have been developed (Servida & Casey, 2019). Although these steps are commendable and necessary, they undoubtedly complicate the collection and analysis of empirical cybersecurity data. As a consequence, adopting Internet evaluation is sometimes challenging and demands the development of novel approaches to assure its correctness and completeness (Valjarevic & Venter, 2013).

9. RECENT ADVANCES AND TECHNIQUES USED FOR CYBERCRIME MITIGATION

Cybercrime is a rapidly evolving threat that poses significant risks to organizations and individuals alike. To address this issue, the cybersecurity industry has developed a range of techniques and technologies aimed at mitigating the impact of cyberattacks. In this paper, some of the recent advances in cybercrime mitigation techniques and their potential to enhance cybersecurity were examined. One significant development in recent years has been the use of artificial intelligence (AI) and ML in cybersecurity. These technologies enable security professionals to detect potential threats and respond to them quickly by identifying patterns of behavior and anomalies in network traffic (Yeboah-Ofori & Brimicombe, 2018).

The advancements in AI and ML contribute to enhancing the precision and efficiency of cybercrime detection through continuous learning from data and adapting to emerging threats. Additionally, the adoption of cloud-based security solutions has become a significant trend. These solutions enable organizations to securely store and process data in the cloud, benefiting from the inherent security features they provide. Cloud-based security offers greater flexibility and scalability compared to traditional on-premises solutions, empowering organizations to monitor and safeguard their systems from any location. Another noteworthy development in combating cybercrime is the utilization of blockchain technology, as highlighted by Ficco et al. (2015). The distributed ledger technology has the potential to create a more secure and decentralized Internet, making it more difficult for cybercriminals to carry out attacks. However, blockchain can be used to secure transactions and prevent fraud, making it an attractive technology for organizations looking to

enhance their cybersecurity architecture (Rathee, 2020). Multifactor authentication is another technique that has gained prominence in recent years. This technology requires users to provide two or more forms of authentication before accessing a system.

This additional layer of security helps prevent unauthorized access to sensitive data and systems, making it an effective way to mitigate the risks of cybercrime. In addition to these techniques, several other recent advances in cybercrime mitigation are worth noting. Threat intelligence involves collecting and analysing data from various sources to identify and prevent cyber threats. Zero trust security assumes that all users, devices, and network traffic are potentially hostile, requiring strict identity verification and access controls for all users. Next-generation firewalls combine traditional firewall technology with advanced security features to provide enhanced security capabilities. Endpoint detection and response detects and responds to threats on endpoints such as laptops, desktops, and mobile devices. Finally, security orchestration, automation, and response automates the response to security events, integrating with various security tools to detect and respond to threats automatically.

10. CYBERCRIME MITIGATION TECHNIQUES

The proliferation of cybercrime has outpaced the ability of traditional forensics-based detection systems to fully prevent or mitigate such attacks. This is largely due to the diverse range of targets (e.g. individuals, banks, businesses, and governments) and motivations (e.g. financial gain, notoriety, sexual exploitation, curiosity) behind cybercrimes, coupled with the constant evolution and adoption of new technologies by cyber-criminals (Yeboah-Ofori & Brimicombe, 2018). Cybercrimes refer to criminal acts, ranging from minor offenses to serious indictable crimes, that are perpetrated through or against computer systems and communication devices (Arfaj et al., 2022). Common examples of cybercrimes include, but are not limited to, cyberstalking, identity theft, credit card fraud, child pornography, cyber laundering, drug sales, cyber terrorism, data breaches, phishing, sexually explicit content, and various types of cyber hacking (Al-Khater et al., 2020). Such offenses often result in breaches of privacy, security violations, financial fraud, business losses, or damage to public or government properties. However, previous studies have been conducted with the objective of devising efficient approaches to detecting cybercrimes. These methods are commonly categorized into various groups, as presented in Fig. 5 and expounded upon in the following sections.

10.1. Machine Learning Techniques

Cybercrime detection using ML techniques has gained significant attention in recent years (Sharma et al., 2021). ML algorithms can be used to analyse large amounts of data and identify patterns, anomalies, and potential threats in various cyber activities. ML incorporates the process of making predictions based on input data, commonly known as training data (Sandoval-Orozco et al., 2020). Through this process, computers acquire the ability to accurately predict suitable outputs for specific inputs using the provided training data.

The learning process can be categorized as either supervised or unsupervised. In supervised learning, the training data consists of input-output pairs, with the outputs referred to as labeled outputs due to their predetermined correctness. In a study conducted by Fortuna and Nunes (2018), they utilized three supervised ML methods (JRip, J48, and Support Vector Machine) to detect instances of cyberbullying in YouTube comments. They also compared a binary classifier and a multi-classifier. Conversely, Al-garadi et al. (2016) proposed a tool for identifying cyberbullying in tweets, where they extracted various features from each tweet to be used in the classifier. They experimented with different classifiers, including support vector machines, naive Bayes, K nearest neighbor, and decision trees, to determine the most effective one.

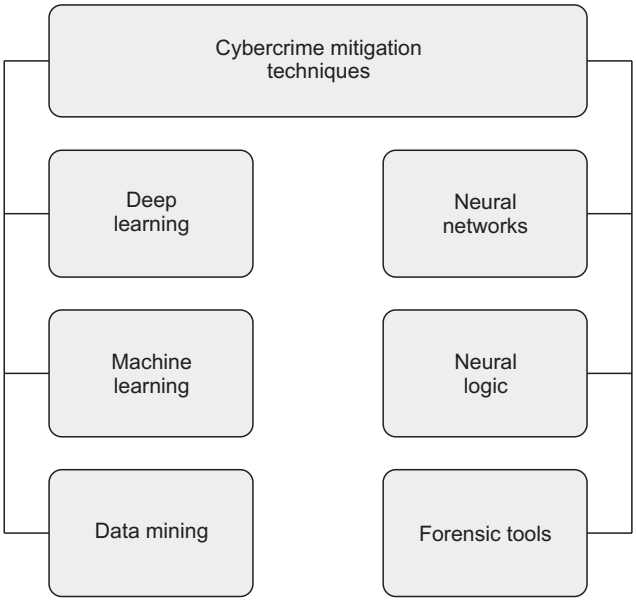


Fig. 5. Cybercrime mitigation techniques.

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The authors concluded that naive Bayes demonstrated superior performance and sufficient strength, based on the findings of Al-garadi et al. (2016). In a similar approach, Uzel et al. (2018) employed text classification to recognize cyber terror and extremism (CTE). Their method involved assigning numerical weights to terms to identify CTE-related vocabulary within texts, followed by converting the document into a vector representation.

10.1.1. Data Mining

Data mining techniques are widely used in the detection of cybercrime (Tommasel & Godoy, 2019). These techniques leverage large volumes of data to identify patterns, anomalies, and relationships that help in uncovering and mitigating cyber threats. Some common data mining approaches in cybercrime detection include anomaly detection, classification, clustering, association rule mining, text mining, and network traffic analysis (Mohammad, 2020). By employing these techniques, organizations can enhance their ability to detect and respond to cyber threats, leading to improved security and protection against cyber-criminal activities (Ukwen & Karabatak, 2021).

10.1.2. Neural Networks

Neural networks, including feedforward neural networks, recurrent neural networks, convolutional neural networks, deep belief networks, and long short-term memory networks, are commonly used in detecting cybercrime (Subba et al., 2018). These techniques enable the processing of complex patterns and temporal dependencies in data, allowing for the identification of known and emerging cyber threats. By leveraging the capabilities of neural networks, organizations can enhance their cybercrime detection systems and improve their ability to combat cyber-criminal activities (Karami, 2018).

10.1.3. Neural Logic

Neural logic techniques can be employed for cybercrime detection by combining neural networks and logical reasoning, resulting in improved accuracy and effectiveness of detection systems (Al-Khater et al., 2020). Here are some ways in which neural logic techniques can be applied:

a) Rule-based learning: Neural networks can be trained to learn rules or logical patterns from labeled data. By integrating logical constraints or rules into the neural network architecture, it becomes possible to capture complex patterns in cybercrime data and incorporate explicit knowledge represented by logical rules. This hybrid approach enables the detection of cybercrime activities based on learned patterns that align with logical rules.

b) Explainable AI: Neural logic techniques enhance the interpretability and explainability of cybercrime detection models. By integrating logical rules or constraints into neural networks, the system can provide human-understandable explanations for its decisions. This helps cybersecurity experts comprehend why certain instances are classified as cybercrime, fostering trust and transparency in the detection process.

c) Fuzzy logic integration: Fuzzy logic, capable of handling uncertainty and imprecise data, can be combined with neural networks to enhance cybercrime detection. Fuzzy logic enables the representation of uncertain or vague rules, which can be integrated with neural networks to handle complex and uncertain cybercrime scenarios.

d) Neuro-symbolic approaches: Neuro-symbolic AI combines neural networks with symbolic reasoning techniques, such as logical inference or knowledge graphs. This integration exploits the statistical learning capabilities of neural networks and the logical reasoning abilities of symbolic systems. By encoding cybercrime-related knowledge into a knowledge graph and training neural networks based on it, the system can leverage the strengths of both paradigms, leading to more accurate cybercrime detection.

However, by incorporating neural logic techniques, cybercrime detection systems can benefit from the combination of neural networks' learning abilities and logical reasoning's rule-based approach, resulting in enhanced detection accuracy, interpretability, and transparency.

10.1.4. Use of Forensic Tools

The use of forensic tools is critical in mitigating cybercrimes. Forensic tools can aid in the collection, analysis, and preservation of digital evidence, which is essential in identifying and prosecuting cyber-criminals (Stoykova et al., 2022). Forensic tools such as digital imaging software can make an exact copy of the data on a device, ensuring that the original data is not altered or destroyed during the investigation process (Servida & Casey, 2019). Data recovery software can also be used to retrieve deleted or lost data that may contain critical evidence. Additionally, forensic tools such as network analysis software can be used to examine network traffic and identify patterns of suspicious behavior (Wu et al., 2020). This can aid in identify-

ing cyberattacks such as DoS attacks, phishing attempts, or malware infections. Furthermore, forensic tools can be used to investigate cybercrimes such as identity theft, cyberstalking, and cyberbullying. Digital forensics techniques can reveal valuable information about the suspect's activities, including their online communications, online transactions, and browsing history (Javed et al., 2022).

11. APPROACHES SO FAR IN MITIGATING CYBERCRIMES

In terms of communication, relationships, and particularly interconnection, the world is growing smaller and smaller every day. The IoT is on the increase, since everything is increasingly linked via the available networks. Various businesses are collaborating to develop sector-spanning interconnections. Because so many people utilize the Internet daily, they lack awareness of the significance of cybersecurity (de Bruijnm & Janssen, 2017). The majority of users only create accounts as required, notably inside their apps, even though they are not designed as robustly as possible. The transmission of information enables the existence of physical infrastructure in cyberspace. If one is unaware of the significance of cybersecurity software, one will not secure devices and systems adequately. Today, we save all of our data on the cloud, so if someone has access to the cloud, they may harm a person technologically (Agrafiotis et al., 2018). These occurrences result in identity theft and monetary losses, among other damages. It is necessary to raise public understanding of the significance of cybersecurity for the populace to comprehend its need. IT department employees have the benefit of recognizing the hazards of cyberattacks and taking the necessary precautions. Even though it is not sufficient inside an organization, malicious hackers will check out and attack the weakest link (Tian et al., 2020).

According to de Bruijnm and Janssen (2017), so many people believe that the cyber-physical society will resolve all issues on its own. They forget that the harm that may be caused might also affect them directly. This ignorance must be erased by educating people on the significance of cybersecurity and the most effective means of achieving it in our society. Cybersecurity is an ongoing issue that needs serious attention from both the government and individuals so that when addressing the problems things will not fall apart. In light of this, cyber threats must be observed in all aspects of our interactions in cyberspace (Maalem Lahcen et al., 2020). To be effective, cybersecurity applications must pay attention to good use of existing cybersecurity knowledge to develop countermeasures against cyberattacks.

However, to tackle these problems the similar attacks that have been mounted must be taken into consideration. The strategies used here will attempt to seal any holes that could have been present in earlier attempts. This is an example of the more common "prevention by elimination" strategy. The things that are already known or thought about should be included as a foundation for cybersecurity. Secondly, new weaknesses in cybersecurity must be constantly reported, meaning getting ready for something that is not manifested and not known. Experts need to be ready for both the known and the unknown threats that may arise anytime (Yaacoub et al., 2022).

12. ANALYSIS OF FINDINGS BASED ON THE REVIEW

Forensic professionals play a crucial role in mitigating cybercrimes by collecting and analysing digital evidence from computer systems and mobile devices. The following are some of the techniques and methods used by forensic professionals in mitigating cybercrimes:

a) Data collection: Forensic professionals collect digital evidence from various sources, including computer systems, mobile devices, and cloud storage. They use specialized tools and techniques to ensure that the data is collected in a forensically sound manner, without altering or damaging the original evidence.

b) Data analysis: Once the data has been collected, forensic professionals use various analytical tools and methods to analyse the evidence. This includes examining file headers, metadata, and other artifacts to determine the source, nature, and extent of the cybercrime.

c) Data recovery: In some cases, digital evidence may be deleted, encrypted, or damaged. Forensic professionals use specialized tools and techniques to recover such data, which may be crucial in establishing the cause and extent of the cybercrime.

d) Data preservation: It is essential to preserve the integrity of the digital evidence throughout the investigation. Forensic professionals use techniques such as write-blocking, hashing, and chain of custody documentation to ensure that the data is not tampered with, changed, or destroyed.

e) Data provenance: Data provenance refers to the record of the sources, usage, update, and processing of data. Forensic professionals use this technique to trace the

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sources and causes of any cyberspace-based issues.

f) Malware analysis: Malware is a common tool used by cyber-criminals to gain unauthorized access to computer systems and networks. Forensic professionals use specialized tools and techniques to analyse malware, which can provide valuable insights into the nature and extent of cybercrime.

g) Network analysis: Cyber-criminals often use networks to carry out their attacks. Forensic professionals use network analysis techniques to trace the source of the attack, identify compromised systems, and determine the extent of the damage.

However, forensic professionals play a critical role in mitigating cybercrimes by collecting and analysing digital evidence from computer systems and mobile devices. They use a variety of specialized tools and techniques to ensure that the data is collected in a forensically sound manner and that the integrity of the evidence is preserved throughout the investigation. By using these techniques and methods, forensic professionals can help to identify cyber-criminals, prosecute them, and reduce the incidence of cybercrime.

13. CONCLUSION

In conclusion, cybercrime is a significant threat to individuals and organizations, and it is essential to have effective measures in place to mitigate its impact. Forensic professionals play a critical role in investigating cybercrime and collecting legally acceptable evidence using modern techniques to handle a large amount of computer and other digital media information. Techniques such as data provenance, malware analysis, memory forensics, and network forensics are valuable tools for forensic investigators in mitigating cybercrime.

However, to be successful in investigating cybercrime, forensic professionals must follow a legally and scientifically appropriate forensic process that respects people's privacy rights. They must ensure that no evidence is tampered with, changed, or destroyed throughout the operation. Additionally, they must keep up with the most current cybercrime issues and mitigating procedures, including new forensic techniques and software. Lastly, as the number of cyber threats continues to grow, forensic professionals must remain vigilant and work together with other cybersecurity professionals to stay one step ahead of cyber-criminals. By utilizing the latest techniques and methods, they can help mitigate the impact of cybercrime and protect individuals and organizations from its damaging effects.

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CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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Publication Metrics and Subject Categories of Biomechanics Journals

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ABSTRACT

Research in interdisciplinary fields like biomechanics is published in a variety of journals whose visibility depends on bibliometric indexing that is often driven by citation analysis of bibliometric databases. This study documented variation in publication metrics and research subject categories assigned to 14 biomechanics journals. Authors, citation, and citation rate (CR) were collected for the top 15 cited articles in the journals retrieved from the *Google Scholar* service. Research subject categories were also extracted for journals from three databases (*Dimensions*, *Journal Citation Reports*, and *Scopus*). Despite the focus on biomechanics for the journals studied, these biomechanics journals have widely varying CR and subject categories assigned to them. There were significant (p=0.001) and meaningful (77-108%) differences in median CR between average, low, and high CR groups of these biomechanics journals. Since CR are primary data used to calculate most journal metrics and there is no one biomechanics subject category, field normalization for journal citation metrics in biomechanics is difficult. Care must be taken to accurately interpret most citation metrics of biomechanics journals as biased proxies of general usage of research, given a specific database, time frame, and area of biomechanics research.

Keywords: citation, field, impact, ranking, research, searching

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1. INTRODUCTION

Biomechanics is a specialized scientific field integrating biology and physics. These two parent disciplines have a long history, while biomechanics is a relatively recently recognized term and field, with the *Journal of Biomechanics* first appearing in 1968. The utility of biomechanics in understanding performance and injury in a diversity of living things and movements has resulted in the establishment of additional biomechanics journals and biomechanics research reports appearing in a wide variety of multi-disciplinary or other-field journals. In addition, no scientific field is completely isolated, and so large electronic databases have increased across-field visibility of biomechanics research and citations. Searching for knowledge, therefore, relies on searching numerous electronic bibliometric database services (e.g., *CINAHL, Dimensions, Engineering Source, Google Scholar* [*GS*]*, Medline, Scopus, Web of Science* [*WoS*]) for peer-reviewed journal articles (Bar-Ilan, 2018; De Groote & Raszewski, 2012; Lascar & Barnett, 2009; Martín-Martín et al., 2021; Meho & Yang, 2007; Ramos-Remus et al., 1994).

The visibility of biomechanics research depends on the indexing of journal articles in databases and the accuracy of the associated search engines (Elkins et al., 2010; Gusenbauer & Haddaway, 2020; Pranckutė, 2021) and promotion of ranked records (Delgado-López-Cózar & Cabezas-Clavijo, 2013; Yamato et al., 2018). Electronic indexing of journals and the articles they publish has been increasingly driven by analysis of citations and citation networks (Garfield, 2006). Journal citation metrics, however, must be field normalized because of large variation in citation patterns across diverse scholarly disciplines (Declaration on Research Assessment [DORA], 2015; Hicks et al., 2015; Seglen, 1997; Waltman, 2016). While field normalization of citation measures is an established principle of bibliometrics/scientometrics/informetrics, operationalization of the most appropriate field reference values remains an unsettled issue (Haunschild et al., 2022; Haunschild & Bornmann, 2022; Leydesdorff & Bornmann, 2016). This present article will use the term *bibliometrics* to refer to all three of the science of knowledge fields noted that focus on these important issues. The limited bibliometric research on biomechanics journals warrants further examination to understand the visibility and interpretation of citation-based metrics of different areas of biomechanics research.

Field normalization is usually based on the assignment of research subject categories to journals indexed by databases, so that journal citation metrics in a field can be scaled to typical values of that field and timeframe. There is considerable variation, however, in how categories are assigned (Bornmann & Marx, 2015; Haunschild et al., 2022; Waltman & van Eck, 2019) and the number (12 to thousands) of subject categories created. There is also variation in results based on the time frame of interest (research front vs. long-term research taxonomies) and computational power (Klavans & Boyack, 2017), article types (Haunschild & Bornmann, 2022), and index effects (Leydesdorff & Bornmann, 2016). Unfortunately, "biomechanics" does not appear as a subject category in major electronic databases and biomechanics has only recently been added to the Classification of Instructional Program codes by the National Center for Education Statistics (U.S. Department of Education's National Center for Education Statistics, 2020). There is little known about bibliometrics of biomechanics journals or subject categories assigned to them by bibliometric databases (Zadpoor & Nikooyan, 2011).

1.1. Bibliometrics of Biomechanics

Knudson and Chow (2008) reported that perceptions of quality or impact of 62 journals publishing biomechanics research by American Society of Biomechanics (ASB) members varied by research interest. A study of publication metrics and the *Journal Citation Reports* (*JCR*) impact factor (IF) of fourteen biomechanics journals over eight years indicated differences in the IF between seven *JCR* subject categories, and there was a slower increase in IF in biomechanics journals compared to other biomedical journals (Zadpoor & Nikooyan, 2011). In this study the biomechanics journals had a mean IF similar (1.2) to sport sciences journals, but lower than for typical biomedical engineering/biomaterials (2-3) and somewhat higher than for mechanical engineering/robotics (0.6-1.2) journals. This mean inflation (0-22% annually) and variation (coefficient of variation [*CV*]=12-21%) of the IF and four other citation metrics was recently confirmed for 14 biomechanics journals in a recent study (Knudson & Quimby, 2023). Given the well-known differences in citation patterns between various sciences and support of this in perceptions of journals by ASB members (Knudson & Chow, 2008) and *JCR* subject categories (Zadpoor & Nikooyan, 2011), additional study was needed within biomechanics journals of likely differences in citation patterns. Assignment of numerous subject categories and overlap across different disciplines are considered evidence of interdisciplinarity of journals (Morillo et al.,

2001).

Field normalization based on citation rates for an interdisciplinary field like biomechanics may be an even greater challenge given research may be published in biological, natural, medical, or many applied science journals. The ASB currently requests that members select from five primary discipline categories: biological sciences, engineering and applied science, exercise and sports science, ergonomics and human factors, and health sciences. This creates challenges to field journal visibility and field normalization due to wide variation in citation rates in numerous subject categories. For example, a study of a similar interdisciplinary field reported substantial differences in subject categories and citation patterns in *JCR* for 100 kinesiology-related journals (Knudson, 2022a).

1.2. Objectives

This current study documented variation in publication metrics of top-cited articles between different biomechanics journals. A secondary purpose was to document the variation of research subject categories assigned to these journals by databases and to determine if there were differences in citation metrics across categories.

1.3. Hypotheses

It was hypothesized that there would be differences in citation and publication metrics of top-cited articles across biomechanics journals associated with different subject categories assigned by bibliometric databases. These data will be important in potential field normalization of biomechanics research and in understanding how databases categorize research in the field.

2. METHODOLOGY

2.1. Journals and Subject Categories

Fourteen journals publishing primarily biomechanics research in the English language were selected for this study (Table 1). This systematic sample was based on previous studies (Knudson & Quimby, 2023; Zadpoor & Nikooyan, 2011), bibliometric indexing, and Internet visibility, and strove to include both long-standing (*Journal of Biomechanics*: 1968-) and more recently established biomechanics-focused journals (*International Biomechanics*: 2014-). Ergonomics/human factors journals related to biomechanics were excluded from the sample because of the large number of highly-cited articles in these journals focusing on psychology rather than biomechanics. The focus on 14 biomechanics-specific journals like previous research (Knudson & Quimby, 2023; Zadpoor & Nikooyan, 2011) avoided different citation patterns and subject categories seen in studies of large samples of multidisciplinary or other journals that only occasionally publish biomechanics-related research (Knudson & Chow, 2008).

Table 1. Median citation rate (CR) and age of top cited articles between three groups of biomechanics journals

Group	Journal	CR	Journal	Age
High	*Gait & Posture*	66	*Journal of Biomechanics*	29
	Journal of Biomechanics	54	*Journal of Applied Biomechanics*	25
	Clinical Biomechanics	52	*Sports Engineering*	21
	J Electromyography & Kinesiology	41	*Clinical Biomechanics*	20
Average	*Medical Engineering & Physics*	38	*Gait & Posture*	20
	Journal of Biomechanical Engineering	23	*J Electromyography & Kinesiology*	20
	Biomechanical Modeling Mech	21	*Biomechanical Modeling Mech*	16
	Comp Meth Biomech Biomed Eng	34	*Comp Meth Biomech Biomed Eng*	16
	Journal of Applied Biomechanics	18	*Medical Engineering & Physics*	16
	Sports Biomechanics	14	*Sports Biomechanics*	15
Low	*J Mechanics in Medicine & Biology*	9	*J Biomechanical Science & Engineering*	14
	Sports Engineering	5	*J Mechanics in Medicine & Biology*	11
	J Biomechanical Science & Engineering	4	*Journal of Biomechanical Engineering*	10
	International Biomechanics	3	*International Biomechanics*	7

Age=2023-year of publication (yr) and CR=Citations/Age (C/yr).

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The consistency of research subject category classification of these journals was examined by extracting the second level subject categories assigned by three bibliometric databases: *Dimensions*, *JCR*, and *Scopus* (Table 2). Journals were searched for using the "Source Title" function in the free version (https://www.dimensions.ai/products/free) of the *Dimensions* database. The "Research Categories" assigned by the database and number of articles indexed were recorded. A university subscription to *JCR* was searched for the subject "Category" associated with the journal titles, and *Scopus* second level categories under "Subject Area and Category" were identified by searching journal titles in *SCImago Journal & Country Rank* (https://www.scimagojr.com) that use *Scopus* data.

2.2. Database and Measures

GS service was selected for journal publication metrics in this study given its superior coverage of peer reviewed journal articles over other subscription databases in all fields of science (Delgado-López-Cózar & Cabezas-Clavijo, 2013; Halevi et al., 2017; Harzing & Alakangas, 2016; Martín-Martín et al., 2018; 2021; Meho & Yang, 2007). This avoids bias in indexing/coverage of the two (*WoS* and *Scopus*) major subscription databases (Pranckutė, 2021); however, this requires extra time in manual review and cleaning of records returned from searches. The high (r=0.78-0.99) associations of citations and subsequent citation metrics for journal articles and authors between *GS* and *WoS* and *Scopus* (De Groote & Raszewski, 2012; Franceschet, 2010; Knudson, 2015a; 2022b; 2023; Martín-Martín et al., 2018; Renjith & Pradeepkumar, 2021) also allow for the conceptual replication and extension of initial research on variation in citation metrics across subject or topical interest areas within biomechanics (Knudson & Chow, 2008; Knudson & Quimby, 2023; Zadpoor & Nikooyan, 2011).

The publication metrics examined in this study focused on areas where previous bibliometrics have reported disciplinary differences: authorship, citations, and field speed/time. The names and number authors of the top 15 cited articles were recorded, and total *GS* citations (C) and the year of publication of each article (Year) were collected. Two additional variables calculated from these variables were article age (Age=2023-Year) and citation rate (citation rate [CR]=C/Age). Article citation rates determine most journal metrics (e.g., CiteScore, IF) and Age was available

Table 2. Second level research subject categories assigned to 14 biomechanics journals by three databases

Dimensions	n	*Journal Citation Reports*	n	*Scopus*	n
Aerospace Eng	1	Biophysics	4	Bioengineering	2
Allied Health & Rehab	8	Eng, Biomedical	9	Biomedical Eng	7
Applied Mathematics	1	Comp Sci, Interdisc Appl	2	Biophysics	6
Biomed & Clin Sciences	4	Neurosciences	2	Biotechnology	1
Biomed Eng	9	Orthopedics	2	Computer Science Applications	2
Civil Eng	2	Physiology	1	Human Computer Interaction	1
Clinical Sciences	3	Rehabilitation	1	Mechanical Eng	2
Cont Eng, Mechtron & Rob	4	Sport Sciences	6	Mechanics of Materials	1
Engineering	10			Medical [misc]	1
Fluid Mech & Thermal Eng	4			Modeling & Simulation	2
Health Sciences	10			Neurology [clinical]	1
Materials Eng	1			Neuroscience [misc]	1
Mathematical Sciences	1			Orthopedics & Sports Medicine	7
Physical Sciences	1			Phy Ther, Sports Ther & Rehab	2
Public Health	1			Physiology [medical]	1
Sports Science & Exercise	9			Rehabilitation	4
				Sports Science	7

Numerals indicate the number of times each subject category was assigned to the 14 biomechanics journals in the study. Only 12 of the journals were indexed in *Journal Citation Reports* and were able to receive a subject category classification from that database.

for all journals, unlike the *JCR* Cited Half-Life. CR also avoids well-known biases in cites per citable articles ratios, like the journal IF that have serious biases and are weakly correlated with individual articles they publish (Abramo et al., 2023; Seglen, 1997; Zhang et al., 2017). The history of publication of each journal (History=2023-Year of first issue) was also recorded.

The "Return articles published in" tool of the advanced search option of *GS* was used for each journal title and variations of journal title. Numerous searches were conducted, and data were extracted from the top 15 cited articles of each journal. The page rank algorithm of *GS* will return up to 1,000 records of any search, and articles are generally listed in descending order by total citations. The investigator reviewed the top 50 returned records to ensure the top 15 records by total citations were obtained. Searches were completed by February 26, 2023.

This study used the top 15 cited articles for each journal following the standard bibliometric practice of focusing on the top percentiles (e.g., 5 or 10%) of citation metrics (Bornmann & Marx, 2014; 2015). There are very strong positive skews of citations and a large percentage of uncited articles in all scholarly fields (Seglen, 1992; 1997; Stern, 1990; Zhang et al., 2017), including biomechanics (Knudson, 2015a; 2015b; 2023), meaning citations to journals are dominated by a small percentage of highly-cited articles. Recent research also indicates that the importance of citation elites is growing in importance (Reardon, 2021). Therefore, this study focused on total citations and citation rates of the top 15 cited articles as a less biased and representative estimate of likely variation and differences in publication metrics across areas of research interest within biomechanics.

2.3. Data Analysis

Extracted data were entered into Excel and rechecked before importing into *JMP Pro 14* (SAS Institute, Cary, NC) for statistical analysis. Descriptive data were calculated for publication metrics across (n=210) all journals and by journal. The research subject categories assigned to these journals were compiled (Table 2).

Given the lack of normality from the large positive skew (Table 3) of publication metrics, subsequent comparison of across journals and subject categories was based on non-parametric Kruskal-Wallis tests. Significant (p<0.025) effects of journal on primary dependent variables (CR and Age) were followed up with comparison across journals split into three groups (High, Average, Low) based on median CR. The three groups were based on rank order of the medians into the top four, middle six, and lowest four journals. Subject categories assigned to these groups were qualitatively compared to explore differences in citation patterns and interdisciplinary in biomechanics journals. Potential interaction of journal history with field speed was examined by correlation of Age with History. The nonparametric statistical analyses precluded effect size calculation, so size of effects were qualitatively based on studies of variation of citation metrics in biomechanics journals (Knudson & Quimby, 2023; Zadpoor & Nikooyan, 2011).

3. RESULTS

All publication metrics were not normally distributed (W=0.68-0.96, p<0.001), showing positive skews (γ=0.89-3.0) and large variability (CV=43-130%) across all biomechanics journals (Table 3). Typical (median and mean) Authors (3 and 4) and Age values for highly-cited articles (17 and 17.3) were less variable across journals than were C or CR. Consistent with this variability, the biomechanics journals were classified into 41 different research subject categories by the three bibliometric databases (Table 2).

Kruskal-Wallis tests indicated significant (p=0.001) difference in both CR and Age between the journals. Ranking the journals by median CR and Age allocation into three groups (Table 1) shows the interaction of C at-

Table 3. Descriptive data of publication metrics of top 15 cited articles in *Google Scholar* from 14 biomechanics journals

Metric	*Skew* (γ)	*Max*	*75%*	M_e	*25%*	*M*	*SD*	*CV*
Authors	1.6	12	4	3	2	3.6	1.6	54
Age	0.9	48	21	17	12	17.3	7.4	43
Citations	3.0	6,310	868	360	125	655	853	130
Citation rate	3.0	274	46	22	10	35	40	114

Variables are: Authors=number of authors; Age=2023-year of publication; Citations=total *Google Scholar* citations; and Citation rate=Citations/Age.
Max, Maximum; 75%, 75th percentile; M_e, median; 25%, 25th percentile; M, mean; SD, standard deviation; CV, coefficient of variation.

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traction and Age in biomechanics. High Age group biomechanics journals include both high CR (e.g., *Journal of Biomechanics*) and lower CR (e.g., *Sports Engineering*) journals. There was a significant (p=0.027) moderate association (r=0.586) between median Age of highly-cited articles of biomechanics journals and their publication history in years.

Disaggregation of journal subject categories in Table 2 by the three CR journal groups shows variation in subject assignments by the bibliometric databases. The number of and variation of subject categories assigned by *Dimensions* and *Scopus* were generally larger for low and average CR groups compared to the high CR group. The high citation rate biomechanics journals generally had the most classifications as health, sports science, and sports medicine research. For example, one hundred percent of the four high CR journals were classified as "Allied Health and Rehabilitation," "Health Sciences," and "Sports Science and Exercise" in *Dimensions*. Seventy-five percent or more of high CR journals were classified as "Sport Sciences" by *JCR*. Similarly, *Scopus* classified seventy-five percent or more journals into "Biophysics," "Orthopedics and Sports Medicine," and "Sports Science." "Biomedical Engineering" classified journals were more common in the average (*Dimensions* and *JCR*) and low CR groups (*Scopus*) than in the high CR group.

4. DISCUSSION

4.1. Biomechanics Journal Citation Metrics

The hypothesized difference in publication metrics within biomechanics journals was supported. There were significant differences in CR and Age of top cited articles published in different biomechanics journals. CR is key input data for numerous journal metrics that are biased proxy estimators of research usage and which must be carefully interpreted (Aksnes et al., 2019; Hicks et al., 2015; Knudson, 2019; Roldan-Valadez et al., 2019). While much of the inquiry and commentary on citation metrics does not clearly define the use of numerous terms (e.g., impact, influence, quality), factor analyses of journal citation metrics clearly align with research usage/popularity or prestige (Bollen et al., 2009; Franceschet, 2010; Leydesdorff, 2009; Leydesdorff et al., 2016; Perera & Wijewickrema, 2018; Walters, 2017; Yan et al., 2011; Zhou et al., 2012). Research on biomechanics and kinesiology journals confirm this two-factor citation metric structure, reporting high associations between usage metrics (e.g., CiteScore, IF, SCImago Journal Rank; Source Normalized Impact per Paper) but with lower associations of these metrics with prestige (Eigenfactor, H Index) metrics (Knudson, 2013; 2015a; Knudson et al., 2023).

Sorting biomechanics journals into three groups by CR (Table 1) shows percentage differences from Average to High and Low groups were between 77 to 108% for CR and 38 to 44% for Age, respectively. These differences have some meaning because they are larger than the 30% variation reported for variability and annual growth of five citation metrics for biomechanics journals (Knudson & Quimby, 2023; Zadpoor & Nikooyan, 2011) or as a standard of meaningful difference in journal metrics from many fields (Amin & Mabe, 2003; Haghdoost et al., 2014; Ogden & Bartley, 2008). This is also confirmatory evidence of meaningful differences in citation rates across research interest areas within biomechanics journals. The current results are consistent with the Knudson and Chow (2008) study of ASB members reporting different perceptions of prestige and quality of biomechanics journals across research areas of interest. It is likely that all journal metrics based on CR create bias in favor or against some research areas within biomechanics because they influence indexing and interpretation based on subject categories with different citation patterns.

Biomechanics journal usage measured by CR also likely interacts with article Age and journal publication history. Inspection of Table 1 shows that a high prestige biomechanics journal like the *Journal of Biomechanics* (Knudson & Chow, 2008) can be influential with high usage (CR) over a long period of time, while other high CR journals (*Gait & Posture*, *Journal of Electromyography and Kinesiology*) may publish highly used research more related to faster and larger health/medical fields of study. Publishing research in a more recently founded and specialized journal will generally be less visible in bibliometric databases that use C and CR to index research, and in turn may lead to fewer citations. The additional C that biomechanics research may attract over time also interacts with well-known differences in speed of decline in citations (e.g., Cited Half-Life) across fields (Haghdoost et al., 2014). There did not appear to be meaningful differences in the number of authors across biomechanics journals. Most highly cited articles had three to four authors, which was consistent with previous research (Knudson, 2012).

4.2. Subject Category and Normalization

The biomechanics journals studied were classified into a wide variety (41) of research subject categories that is consistent with a previous study of *JCR* categories for

biomechanics journals (Zadpoor & Nikooyan, 2011). The classification of many categories with similar sets of journals has been reported in biomedical sciences (Rafols & Leydesdorff, 2009; Wang & Waltman, 2016) and is also consistent with bibliometric interpretation of complex or interdisciplinary fields (Katz & Hicks, 1995; Morillo et al., 2001). In addition, the subject categories assigned by databases across the three CR groups were generally consistent with previous research, indicating that health and biomedical journals have higher citation rates than journals classified into engineering, education, or behavioral sciences (Jacso, 2005; Mongeon & Paul-Hus, 2016; Pozsgai et al., 2021; Wu et al., 2012). There is, however, well known inconsistency in assignment of and specific subject categories across databases (Bornmann & Marx, 2015; Haunschild et al., 2022). For example, this study found relatively higher CR in *GS* for the similar "Sport(s) Science(s) and Exercise" subject that also overlaps with several categories in all databases examined (Allied Health and Rehabilitation, Rehabilitation, and Orthopedics and Sports Medicine).

All these observations support the hypothesis that biomechanics journals may not be easily described with one citation rate on which to base field normalization of journal metrics. The overall median CR of 22 to 26 citations/year (Tables 1, 3) in *GS* was similar to studies of top cited articles in *GS* in a study of the journal *Sports Biomechanics* (Knudson, 2020) and seven biomechanics journals within a study of 65 kinesiology journals (Knudson, 2014). However, prestigious (e.g., *Journal of Biomechanics*) and biomedical journals (e.g., *Gait & Posture*; *Clinical Biomechanics*) tend to have CR twice as high. Newer journals (e.g., *International Biomechanics*) and specialized engineering journals (e.g., *Sports Engineering*) may tend to have 77% lower CR. It is important to not take these general percentages literally as likely differences in specific articles' future citation potential or any other construct (impact, quality, or prestige).

Citation data are not true ratio level measurements due to differences in indexing and errors. Thus, journal metrics calculated with CR, their reporting with false precision, and subsequent efforts to rank journals have received international rebuke (Declaration on Research Assessment [DORA], 2015; Hicks et al., 2015) and are described as inaccurate, an insidious misuse, or a mania (Adler et al., 2008; Amin & Mabe, 2003; Casadevall & Fang, 2014; Knudson et al., 2023). Most articles published in a high CR and consequently high IF journal, however, do not receive high citations and CR because of skewed citations and the large percentage of uncited articles in journals (Knudson, 2015b; 2023; Seglen, 1992; 1997; Stern, 1990; Zhang et al., 2017). A high CR or IF journal merely has some highly cited articles in a specific time window relative to other journals that should only be used for comparison if they are from a similar field.

It is also important to note that CR and journal metrics vary by the database used and year for their calculation due to different indexing and errors (Franceschini et al., 2015; Meho & Yang, 2007; Moed et al., 2016; Rossner et al., 2008). In biomechanics, for example, Zadpoor and Nikooyan (2011) reported that the two-year IF varied from 1 to 3 across six *JCR* subject categories between 2002 and 2010. Biomechanics journals classified as "Sport Sciences" had a 2010 IF of about 2, while a more recent study reported eight biomechanics journals related to kinesiology in 2020 had a five-year IF of 2.7 and 27 Sport Science journals had a mean five-year IF of 4.0 (Knudson, 2022a). Persons seeking to field-normalize citation metrics for biomechanics journals, research, or authors should specify specific reference data based on both subject categories and the database used.

4.3. Limitations

Several limitations of this study should be considered in interpreting the results. Citation data were limited to the top 15 cited articles in *GS*. While CR forms the base of numerous journal metrics, it is often unclear how C and CR change by subsequent citable document rate calculations. There are well-known differences in journal metrics that are all based on CR and well-known differences in the size of the same journal metric calculated from different databases, which all influence the current results. The high positive correlation between citations between different databases and several results in the current study consistent with previous research supports the accuracy and potential utility of the current results. Future research is recommended to help clarify research subject categories and differences in CR and journal metrics for biomechanics research.

5. CONCLUSIONS

It was concluded that the interdisciplinary and application diversity of the field of biomechanics leads to substantial variation in citation rates in research published in biomechanics journals. This is reflected in variation in research subject categories associated with biomechanics journals by three major bibliometric databases. The lack

of a unique biomechanics category, numerous reference categories, and the meaningful difference (77 to 108%) from low to average and high CR biomechanics journals, make field normalization with subsequent journal metrics difficult. Care must be taken to accurately interpret most citation metrics of biomechanics journals as biased proxies of general usage of research, given a specific database, time frame, and research topic.

CONFLICTS OF INTERST

No potential conflict of interest relevant to this article was reported.

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Essential Competencies for Digital Workforce of Provincial Office in Thailand Using Delphi Technique

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ABSTRACT

This study aimed to study its required performance requirements and proposes a competency framework necessary for the digital workforce of the Provincial Offices in Thailand. The specific primary informants were determined as 17 people. The collecting process was performed using the Delphi technique and the electronic Delphi technique in two phases, totaling four rounds. In the first time, a structured interview was used to conduct online interviews for 15 people. Content validation was performed to determine issues of the competency framework essential for the digital workforce with 7-level scaled questionnaires, and then online reviews were collected between 10-15 people (2nd to 4th times). A consensus was found and confirmed four times with descriptive statistics, namely frequency, mean, standard deviation, mode, median, and the absolute value of the difference between mode and median, interquartile range, and application of the conceptual framework. The research findings revealed that the essential competency requirements for the digital workforce were covered in digital literacy (six aspects), digital skills (four aspects), and digital characteristics (four aspects). Consensus was confirmed for 84 issues. Therefore, it was concluded that 61 points for building an essential competency framework for the digital workforce made them effective in using digital technology as a labor-saving instrument, as well as for expanding the breadth of development of digital expertise to include members of the organization's digital practitioner network. This development will benefit government agencies and the private sector, both national and international, in the future.

Keywords: Delphi technique, essential digital competency, digital workforce, government organization, provincial office in Thailand

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1. INTRODUCTION

The innovation system is a critical factor in the overall competitiveness of regional and national economies (Samara et al., 2023). Therefore, digital technology has become an issue of public policy according to policy information publication and geographic restriction (Setthasuravich & Kato, 2022), which is a basic factor leading to digital government in the future. For example, the Canadian government proposed to develop a framework and integrated format according to characteristics and agencies that were expected to create the communication, sharing, publication, and information access caused by using digital equipment and various resources for transportation and record keeping (Kupfer, 2022; Taher, 2015). The Singapore government outlined a plan to transform its economy, government, and society through a digital economy framework called the 'Digital Government Blueprint,' which set goals for success to achieve digital transformation of public services by 2023. For Thailand, the goal was to increase the potential of the digital workforce and to increase awareness and digital skills by driving programs that promote the creation of talent and professionals in digital technology and innovation, to enhance digital skills for the general public toward a dynamic digital economy based on a scholarly society, workforce, and digital innovation (Digital Economy Promotion Agency, 2018).

Therefore, the adoption of digital technologies and the replacement of non-digital processes with digital ones have led to organization-wide transformation and the emergence of new business models (Radziwon et al., 2022; Verhoef et al., 2021) or modifying existing ones, focusing on the technological aspect, such as optimizing operational processes within the organization (Dąbrowska et al., 2019; Vial, 2021). As a result, there has been an ever-increasing demand for digital competencies worldwide (New Zealand Digital Skills Forum, 2017). Siddoo et al. (2019) showed that the talent of a digital workforce in the digital age strongly influences the nature of digital technology jobs and the demand for a digital workforce. But there still remains a gap in the top five competency requirements: lifelong learning, personal attitude, teamwork, credibility, and digital fundamentals. Additionally, a review of 70 empirical papers between 2010 and 2022 identified essential characteristics of labor change: (1) the digital capabilities of a person, (2) digital culture, (3) digital workspace, (4) empowerment, participation, and motivation, (5) presenting and expressing a shared vision, and (6) transformational leadership and governance (Alrasheedi et al., 2022). To achieve workforce transformation, essential skills were also promoted, such as communication, openness, positive attitude, critical thinking, empathy, and potential training through face-to-face role play (Konstantinidis et al., 2022). The conclusion was that a diverse workforce of gender, age, color, and digital capabilities requires flexibility and balance between life, family, work, education, and digital society (Wong et al., 2020). Therefore, the model organization should respond to its work in the integrated environment of the workforce, which is necessary to receive skills and new potential from personnel, to balance the arrangement of different workplaces with the process of integrating the digital workplace in the digital age, especially those digital workforces in organizations that need to develop their digital capabilities. This was consistent with provincial and national strategic plans. According to the insights of Weritz (2022), it was found that responsible digital thinking, digital literacy, change skills, personal development skills, communication skills, community management skills, data analysis skills, and web development skills are critical in the digital workplace. This considers employees as the top priority for digital transformation, and highlights employee-level innovation in the workplace (Ahmed et al., 2022).

Under the provincial office in Thailand, there is a group called the Strategy and Information Technology Development Division, which employs computer technicians who are considered essential digital human resources. They are responsible for carrying out digital tasks related to the mission and responsibilities of information technology in order to drive organizational development in accordance with the country's digital technology plans and policies (Office of the Council of State, 1991). Therefore, it is important to establish a digital infrastructure foundation to benefit from digital technology in maintaining digital security, supporting public culture with technology, and preparing a suitable working environment for collaborative technology use, including the safe use of data related to digital technology. They possess wisdom and responsibility for continuous learning (Smart Nation Singapore, 2018). The scope of digital capabilities includes data, communication, content creation, security, and problem-solving abilities (Ragnedda & Kreitem, 2018). This aims to create an efficient digital workforce that can integrate and utilize technology (Basilotta-Gómez-Pablos et al., 2022) to generate new jobs that develop alongside technological advancements (Pesch, 2021), leading to two research objectives: firstly, to define the necessary competencies and propose an essential competencies framework for digital

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personnel in the regional offices of Thailand and, secondly, for planning digital workforce development that aligns with management platforms and supports digital changes according to the digital economic and social development plan of Thailand from 2018-2037, enabling digital integration and keeping pace with continuous global digital transformations.

2. RELATED LITERATURE

2.1. Digital Workforce Concept

The concept of a digital workforce in this research was a human-centered approach that was part of skilled human capital and provides them with sustainable, suitable employment opportunities. As organizations transform into the digital workplace, it becomes a real challenge to manage the digital talent of employees (Cooke et al., 2022). The definition of the digital workforce is employee transition from traditional/semi-traditional production to fully automated systems (Cooke et al., 2022), which encounters outdated skills in some workforces. This meant that some of the roles and skills need to be recovered. It was estimated that 30% of the workforce is forced to do different jobs, low-skilled and high-skilled, and inevitably needs to change careers and occupations and their skill levels. The result has been the creation of millions of new jobs requiring new skills (World Economic Forum, 2020) based on the flexibility of qualifications and defined digital competency targets (Chaerunisa et al., 2022). Therefore, it is necessary to develop all-new abilities. The same applies to the digital workforce working in computer academic positions; according to the workforce structure and division of labor within the provincial government under the Ministry of Interior, Thailand, it is necessary to have roles, features, and capabilities in digital operations.

2.2. Knowledge and Skill of Digital Workforce of the Provincial Offices in Thailand

In this research, conceptual approaches related to digital workforce competency involve using and supporting basic information technology skills and using computers to retrieve, evaluate, store, produce, present, and exchange information (European Union, 2006). The role of digital literacy in the workplace was to transition towards a management style oriented around digital technology (Dery et al., 2017; Hanelt et al., 2021a), as well as pointing out that it is necessary to recognize and support an organization's digital innovation efforts (Hanelt et al., 2021b; Kohli & Melville, 2019; Wrede et al., 2020). Moreover, digital competencies are required for general management or leadership in the digital age (Furr et al., 2012; Volberda et al., 2021). These fulfill the requirements appropriately and are flexible enough to adapt to different digital situations. Moreover, protection against rapidly obsolete structures is required (Bartolomé et al., 2022); for example, skills to transform digital literacy could be classified into five aspects: (1) data and information literacy, (2) communication and collaboration, (3) digital content creation, (4) security, and (5) problem-solving. This describes capabilities in general terms and is technologically neutral. A deep understanding of the technology capable of analyzing data and creating scenarios, simulations, and insights is also needed (Wu, 2022). Thereby, the knowledge dimension is the acquisition and retention of specific information, specific contexts, or rules for exchange. The skill dimension is communication or showing different behaviors of people. This results in successful discussions (Sue, 1998; Sue et al., 1992).

2.3. Characteristics and Functional Roles of Digital Workforce of the Provincial Offices in Thailand

General knowledge, mental ability, behavior and attitude, emotional management, personal relationships, and goals (Cunningham et al., 2022) are prerequisites for a digital workforce looking to manage learning and digital technologies. Therefore, stimulating the integration of that behavior is necessary. Furthermore, the hierarchical structure in the team division, in particular, is a contextual factor resulting from the influential role of senior management (Firk et al., 2022). Furthermore, interdependence, enhanced by networks, facilitates collaboration and innovation, manages complex social issues, augments governance, and collectively steers the development and implementation of policies (Gray & Purdy, 2018; Larsson, 2020). This transformation encompasses shifting towards more open, egalitarian interpersonal relationships while diminishing hierarchical structures. It primarily entails improvements in several key areas, namely: (1) work-life balance, (2) flexibility, (3) versatility, (4) alignment of values, and (5) the enhancement of work meaningfulness (Hofmann et al., 2019), all of these focusing on inspection, acceptance, utilization, and the significant advancement of digital technology (Beliaeva et al., 2020; Nambisan et al., 2018; Olsson & Bernhard, 2021; Srinivasan & Venkatraman, 2018). Therefore, achieving a balanced and accurate digital career path discovery should be prioritized, starting with strategic digital business model support, digitalizing the process of strategic digital platform sup-

port, and building a digital ecosystem (Bartolomé et al., 2022), as well as stimulating the inclusion of behaviors under specific traits of digital innovation with the behavioral integration of digital knowledge (Buyl et al., 2011; Georgakakis et al., 2017) and emphasis on skill level enhancing coordination roles (Firk et al., 2021; Kunisch et al., 2022; Singh et al., 2020). These objectives were linked to the need for success theory. This reflects a sense of accomplishment by striving to achieve one's career goals (McClelland, 1961). Positive intercultural relationships, and values embedded in the environment, preferences, and awareness of importance, are the deepest part of the culture in that environment (Bukowski & Rudnicki, 2019; Gao et al., 2020; Okada et al., 2021). Individuals with aspirations for high achievement proactively engage in significant endeavors motivated by a deep-seated desire for success. They consistently pursue success, driven not only by goal orientation but also by a lasting aspiration for the psychological satisfaction that results from achieving desired outcomes (Furnham, 2021).

Therefore, the above information could be considered as concepts and principles of digital competency, which had many issues. The researcher asked the research questions, "What are the competency requirements required for the digital workforce of the Provincial Offices in Thailand?", and "What should be the ideal competency framework for an effective digital workforce in these offices?" The summaries were synthesized to form a conceptual framework for the study, shown in Fig. 1.

3. METHODOLOGY

The Delphi technique is a method of collecting and organizing the results of expert group opinions and decision-making regarding consensus answers. This involves gathering answers in a series of interviews and using systematic consensus checks on specific issues through the design of questionnaires to collect feedback and summarize opinions as a consensus in each successive round (Balasubramanian & Agarwal, 2012). Following the feedback-response process for decision-making (Novakowski & Wellar, 2008), this is a method for validating potential conclusions based on the highest possible level of expertise (Glass et al., 2022), covering diversity in the researcher's focus group, regardless of the conversation, including reflections on individuality, identity, and sensitive contexts (Milani & Borba, 2022). The approach was receptive to creativity, innovation, and discovery, fostering a sense of responsibility (Jarzabkowski et al., 2021), and more practical application of new ideas, processes, and design procedures (Lê & Schmid, 2022). Personalization and linguistic diversity (Daft & Lengel, 1986), together with the integrated Delphi technique between the Delphi technique and Delphi electronics technique (von der Gracht, 2012), achieved flexibility and suitability in the current context. This allowed the researcher to uncover

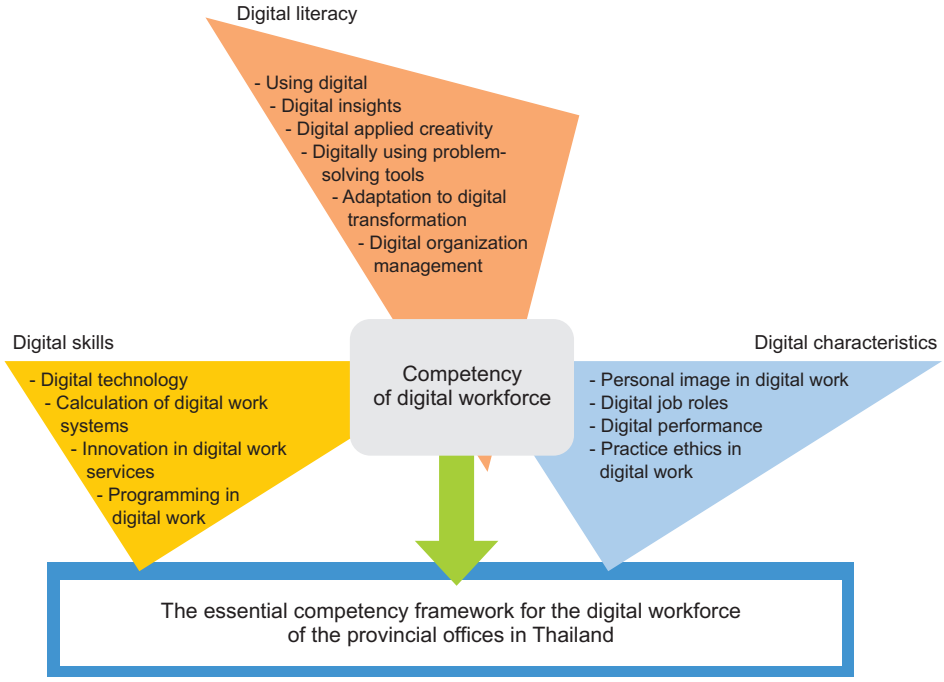


Fig. 1. Conceptual framework for studying the competencies needed for digital workforce in Thailand.

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new insights from exploring specific social contexts by utilizing channel interviews to simultaneously send and receive verbal and non-verbal messages. Furthermore, the process could personalize and prevent multilingualism. A distinguishing feature of Delphi research was that a group of experts was free to provide answers but could not know the answers or details of the experts who were primary informants. This study was approved by the Human Research Ethics Committee, Khon Kaen University, number HE643217, certified on 24 November 2021.

The population studied in this research consists of individuals who work and are involved with the digital workforce in Thailand. Since the actual population size is unknown, a targeted selection method was used to select primary data sources. This includes individuals working or responsible for digital technology under provincial offices, experts working or responsible for digital technology in public and private sectors, those involved in the digital workforce, and experts from educational institutions who contribute to teaching and research in producing digital technology personnel. They represent the research study as representatives for the research objectives. The discrepancy was between 0.02-0.50 (Macmillan, 1971), totaling 17 people, divided into groups of organizational personnel (12 people, including six executives and six digital workforces), and a group of digital technology experts (5 people, including two digital workforce development experts and three digital workforce production experts). However, if the leading informant group needed help providing information, each region's provinces would be selected instead according to the population. The three criteria for the exclusion of informants from the research were defined as follows: (1) they do not meet the qualifications specified in each group, (2) they fail to provide consent and complete cooperation in providing information by the completion of the data collection process, and (3) consent to participate and cooperate by providing information was incomplete; participants reserved the right to withdraw prior to the completion of the data collection process.

Conducting research using the Delphi technique was an efficient and fast data collection process, starting with brainstorming. This was followed by assessment and screening to ensure a unanimous consensus (Nayahangan et al., 2019), generated as an electronic survey with anonymous and confidential responses. This provided independent feedback and limited the risk of bias affecting the outcome (Karstensen et al., 2018; Nayahangan et al., 2018; 2019). An approach to concept and framework development (Rowe & Wright, 2011), especially in research on professional learning with an iterative process, avoids groups' dynamic bias (Harteis, 2022). Data collection and knowledge had to be built on informed opinions, subjective expert judgments, and experiential interpretations (Winkler & Moser, 2016). Obtaining group opinions from individual primary informants (Landeta & Barrutia, 2011) allowed input from large and geographically dispersed cohorts. There were always multiple rounds to include around the generation of ideas. The first round needed to be more structured. This gave each primary informant an independent scope to identify and elaborate on issues they deemed necessary (Hartland-Rowe & Wright, 1975). In this research, work was divided into two phases according to the 2-step Delphi technique (Judd, 1971) as follows:

> Step 1: The determination of the topics studied, leading to structural and operational policy formulation.

The first phase focused on the study of competency requirements for the digital workforce of the Provincial Offices in Thailand (1st time). The steps involved in Phases 1 and 2 are included in Fig. 2.

The research instrument was a structured interview with in-depth information about the questionnaire (Crabtree et al., 1993), generated from a synthetic review of secondary data. This was a set of two open-ended questions. It consisted of an interview form for corporate personnel and digital technology experts. The quality of the tools was examined by five experts knowledgeable in digital technology, competency, and social science research statistics, with rates of +1 (consistent), 0 (unsure), and -1 (inconsistent). The Index of Item Objective Congruence method was used to analyze the results. It was found that the consistency of the question items was between 0.80-1.00, indicating that both interview forms had content validity (Rovinelli & Hambleton, 1976).

The initial data collection was conducted by developing an interview form using Google Forms, a method employed to gather empirical data pertinent to qualitative and quantitative research (David et al., 2023). This approach enabled experts to freely provide information and respond to inquiries (von der Gracht, 2012). The form was disseminated via online channels, including Line, Facebook, and Email, to facilitate accessibility and participation. When the primary informant had to participate in the interview in person or via online platforms such as Line, Facebook, or Zoom, they chose individual interviews. Maintaining the anonymity of responses is a key aspect of the Delphi technique. Iterative surveys used di-

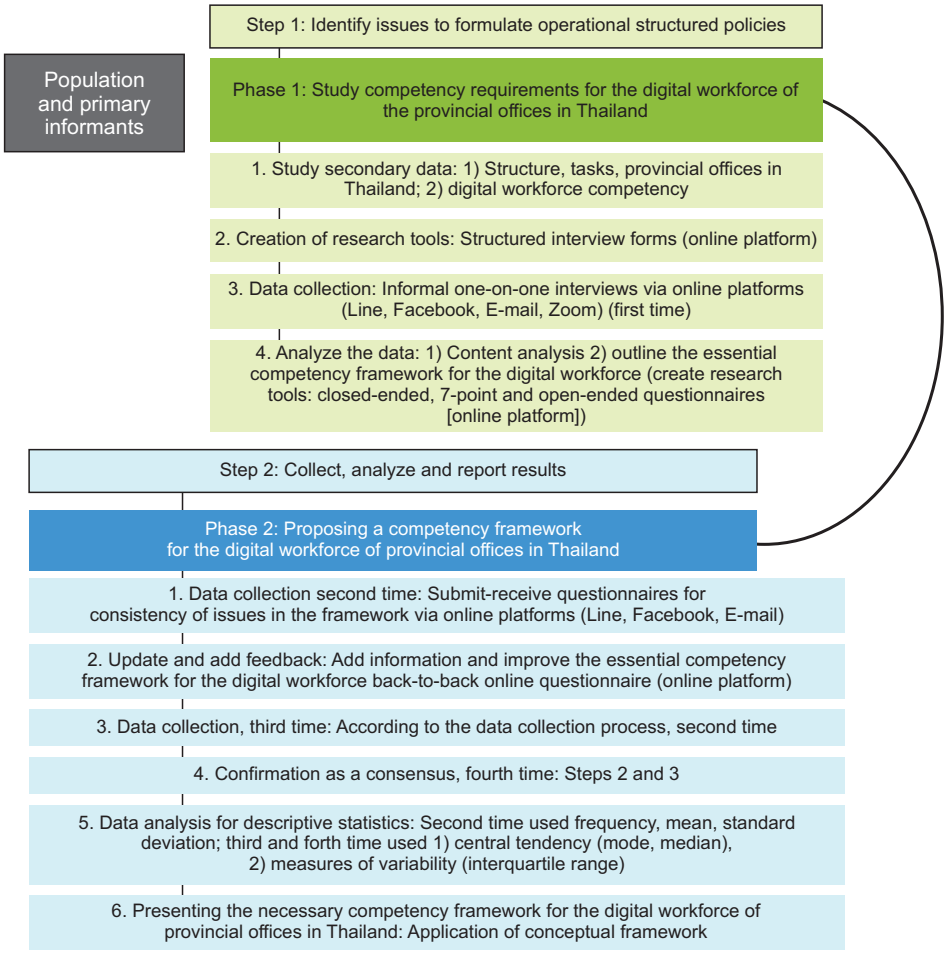


Fig. 2. Implementation of research data collection using Delphi techniques and Delphi electronic techniques.

verse groups and solving differences to achieve the goal of maximum consensus (Gupta & Clarke, 1996; Guzys et al., 2015), with a total of 15 people, representing 88.23%, consisting of 10 corporate personnel (66.67%) and a group of five digital technology experts (33.33%). This was consistent with the observations of Creswell and Creswell (2017) that guidelines determine the appropriate sample size in qualitative studies. Depending on the research design and saturation, there could be 1-30 participants.

Data analysis uses the method of analyzing the content region, connection, and relationships (Steiner et al., 2007) by using short or long statements with latent content analysis on the fundamental aspects of the phenomenon under consideration (Boyatzis, 1998; Vears & Gillam, 2022) that were relevant to the question. The research was used to outline the competency required for the digital workforce of the Provincial Offices in Thailand through a closed-ended questionnaire. A 7-level assessment scale (Chan & Idris, 2017; Vagias, 2006) allowed for assessing different levels of importance, agreement, or even quality (Claveria, 2018) and appropriateness before being used to collect data in Phase 2.

Step 2: Collection, analysis, and reporting of study results (2nd, 3rd, and 4th, unanimous confirmation of concordance).

The second phase of the project proposed the necessary competency framework for the digital workforce of provincial offices in Thailand. Data collection was created as a closed-ended questionnaire in an online form using Google Forms delivered via online channels (same as Phase 1, Time 1) with the primary informants as follows: for Time 2, a total of 15 people (there was a synthesis of each issue); for Time 3, a total of 10 people (reviewing issues and adding feedback); and for the 4th time, 10 participants were able to confirm their consensus to determine the importance of each case and reach agreement in the end (Gupta & Clarke, 1996; Guzys et al., 2015).

Descriptive statistical methods were employed to ana-

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lyze the data, facilitating an understanding of key metrics such as the maximum and minimum values and the overall data distribution (Sudarto et al., 2020). Initially, this involved calculating the frequency, mean (M), and standard deviation (SD). Subsequently, measures of distribution, including the quartile range, were examined. The interpretation of the calculated median was conducted by Best (1970)'s criterion. According to this criterion, a median value of 3.50 or higher was deemed necessary to indicate consistency in the data. Subsequently, the standard for interpreting the interquartile range was defined by the methodology proposed by Glass and Hopkins (1996). This involved calculating the difference between the first and third quartiles. A resultant value not exceeding 1.50 was indicative of consistency in the opinions of the expert group regarding each question in the report. Finally, the criteria for interpreting the mode results were established based on Flanders (1988)' guideline, which stipulates that the absolute difference between the Mode and Median should not exceed 1. This criterion was adopted to ascertain the uniformity of opinions within the expert group.

For presenting the necessary competency framework for the digital workforce of provincial offices in Thailand with the application of the conceptual framework, the researcher visualized the understanding of concepts, subconcepts, and relationships between concepts in a mind map (Kwon & Cifuentes, 2009). The relationship between concepts in the mind map consisted of open-ended ideas, connecting lines, phrases, and concept map structures linked. The researcher chose terms for ideas similar to the respondent's knowledge to characterize overall coverage and associations between categories (Cañas et al., 2013; Ruiz-Primo, 2000; Ruiz-Primo et al., 2001; Watson et al., 2016). The researcher synthesized the results derived from consensus-building exercises to construct a competency framework essential for the digital workforce in Thailand's Provincial Offices.

4. RESULTS

4.1. Competency Requirements Needed for the Digital Workforce of the Provincial Offices in Thailand

4.1.1. Summary of Competencies for Digital Labor in Thai Provincial Government Offices

This initial phase of data collection, utilizing the Delphi technique with a primary informant group, encompasses findings presented in Tables 1-3, detailing essential skills for digital tasks in provincial government settings in Thailand.

4.1.2. Delphi Study Findings on Essential Competencies for Digital Labor in Thailand

Identifying essential competencies for digital labor in Thailand was derived from the insights of a primary cohort of 15 data contributors, utilizing the Delphi technique in its second round and second iteration. The findings were as follows: 1) In digital literacy, scores ranged from high (5) to high (6). The highest score (6) was attributed to digital usage and adaptation to digital transformation, as indicated by 13 respondents. Following this, digital applied creativity was noted by 12 respondents.

Table 1. Summary of competency requirements required for digital workforce digital knowledge dimension

Dimension	Requirement
Digital literacy	Knowledgeable, spacious, clean, modern, and timely digital innovation is designed and developed with the old technology to the new one with expertise for continuous use
1. Digital use	Using computers, the Internet, management program presentation programs, computer security applications for daily career, and self-development
2. Digital understanding	Thinking, searching, filtering, discriminating, analyzing, synthesizing, and using digital tools to create, modify, communicate, disseminate, share, monitor, and supervise digitally
3. Digital applied creativity	Inventing, innovating, and processing together with digital technology concepts in the form of digital creation for managing and providing digital services
4. Digitally using problem-solving tools	Use equipment, technology, knowledge, programs, processes, and formats to solve problems arising from digital operations and services
5. Digital transformation adapting	Changing habits and behavior to improve, correct, develop, and reform operations, operations, and digital services
6. Digital organization management	Selection and recruiting digital technology increases productivity and adds value to the work process and digital workforce management according to plans and projects

Table 2. Summary of essential competency requirements for digital workforce; digital skills

Dimension	Requirement
Digital skill	Specific skills were amalgamated with knowledge, predicated on the requisite digital technology, to foster a novel digital work ecosystem, thereby augmenting professional competency in alignment with the demands of digital labor
1. Digital technology	Bringing modern scientific knowledge to apply digital work to achieve operational results and deliver digital services
2. Digital systematic calculation	The results were systematically deduced through computational science, leveraging knowledge of digital technology. This involved the integration of complexity characteristics into a coherent sequence, guided by specific digital technical logic, for developing a system encompassing information and technology
3. Digital service innovation	Finding ways to create new digital innovations and different digital work services, with principles, processes, steps and concepts, technical theories, and specific digital techniques to benefit the organization, colleagues, and service users
4. Digital programming	Writing a list of commands, a set of instructions written in a computer language to work with information systems and digital programs according to established procedures

Table 3. Summary of essential competency requirements for digital workforce; digital characteristics

Dimension	Requirement
Digital characteristics	A digital work environment, as measured by roles and performance, is achieved accurately, reasonably, and transparently to all parties
1. Digital personal image	Showing gestures and behaviors requiring communication about facilitation, service delivery, and digital performance to society
2. Digital function role	The requisite status for conducting digital activities and operations must be underpinned by a conscientious awareness of responsibility and a commitment to ethical practice
3. Digital performance result	Ability to perform tasks effectively following the organization's digital objectives and goals
4. Digital ethical practice	Acting and proceeding following guidelines for conduct based on moral principles rationally, distinguishing what is right and what should and should not be done, not selfishly encroaching on one another, and following the rules, conventions, laws, and regulations related to digital work

Nine respondents acknowledged using digital tools for problem-solving and digital organizational management, while eight respondents ranked digital understanding last. 2) For digital skill dimensions, the scores varied from moderate (4) to high (6). The highest score (6) in this category was for digital service innovation, as reported by 14 respondents. This was followed by digital technology and digital systematic calculation, noted by 12 and 6 respondents, respectively, with digital programming being the least mentioned by four respondents. 3) Regarding digital characteristics, the scores again ranged from high (5) to high (6). The top position, with a score of (6), was for the role of digital function, as identified by 12 respondents. There were three areas with equal scores: digital personal image, digital performance result, and digital ethical practice, each cited by ten respondents. These results are detailed in Table 4.

4.1.3. Ranking and Analysis of Competency Dimensions for Digital Personnel in Thailand's Provincial Offices

The computation of the mean and standard deviation for the competency requirements essential for digital personnel in Thailand's provincial office sector was conducted based on the inputs from a primary group of 15 data contributors, employing the Delphi technique in its second round and iteration. The results indicated a high level of competency across all dimensions (M=5.62, SD=0.03). The dimensions were ranked in descending order of importance as follows: (1) The Digital Literacy dimension exhibited the highest mean (M=5.69, SD=0.09), with Digital Applied Creativity leading within this category (M=5.90, SD=0.40). (2) The Digital Characteristics dimension followed closely (M=5.68, SD=0.09), with the Digital Function Role being the most prominent aspect (M=5.79, SD=0.31). (3) Lastly, the Digital Skills dimen-

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Table 4. Summary of the frequency of the competency requirements required for the digital workforce of the provincial offices in Thailand (n=15)

Dimension	Number (issue)	Frequency (n)						
		Not have (1)	Little (2)	Quite a bit (3)	Moderate (4)	Quite a lot (5)	A lot (6)	The most (7)
Digital literacy	56							
1. Digital use	12	-	-	-	-	2	13	-
2. Digital understanding	10	-	-	-	-	7	8	-
3. Digital applied creativity	6	-	-	-	-	2	12	1
4. Digitally using problem-solving tools	7	-	-	-	-	5	9	1
5. Digital transformation adapting	9	-	-	-	-	2	13	-
6. Digital organization management	12	-	-	-	-	6	9	-
Digital skill	33							
1. Digital technology	8	-	-	-	-	3	12	-
2. Digital systematic calculation	9	-	-	-	-	9	6	-
3. Digital service innovation	9	-	-	-	-	1	14	-
4. Digital programming	7	-	-	-	3	8	4	-
Digital characteristics	50							
1. Digital personal image	11	-	-	-	-	5	10	-
2. Digital function role	10	-	-	-	-	3	12	-
3. Digital performance result	15	-	-	-	-	5	10	-
4. Digital ethical practice	14	-	-	-	-	5	10	-
Total	139	-	-	-	-	-	-	-

sion (M=5.49, SD=0.14) was identified, where Digital Service Innovation was ranked highest (M=5.73, SD=0.17). These findings are comprehensively detailed in Table 5.

4.2. Presenting the Necessary Competency Framework for the Digital Workforce of the Provincial Offices in Thailand

This discovery confirms a consensus on various issues within the framework of competencies necessary for digital personnel in the regional office sector of Thailand. The data were obtained from a questionnaire survey conducted with a main group of 10 data providers, using the Delphi technique, round 2, iteration 3, and were further confirmed as a consensus in round 4. It was found that there was a consensus level of consensus on all dimensions (3 dimensions), all aspects (14 aspects), and all issues (84 issues). The interquartile range (IQR) was not over 1.50, and the median (Mdn) was between 5.00-6.00, indicating the most consistent, and the absolute value of the difference between the mode and the median was between 0.00-0.50. When classifying as a digital knowledge dimension (6 aspects, 28 issues), it was found that the IQR was

Table 5. Mean and standard deviation of competency requirements required for digital workforce in Thailand (n=15)

Dimension	Number (issue)	M	SD	Meaning	Rank
Digital literacy	56	5.69	0.09	A lot	1
1. Digital use	12	5.76	0.34	A lot	4
2. Digital understanding	10	5.43	0.30	A lot	6
3. Digital applied creativity	6	5.90	0.40	A lot	1
4. Digitally using problem-solving tools	7	5.80	0.51	A lot	2
5. Digital transformation adapting	9	5.78	0.27	A lot	3
6. Digital organization management	12	5.47	0.30	A lot	5
Digital skill	33	5.49	0.14	A lot	3
1. Digital technology	8	5.63	0.23	A lot	2
2. Digital systematic calculation	9	5.45	0.24	A lot	3
3. Digital service innovation	9	5.73	0.17	A lot	1
4. Digital programming	7	5.16	0.49	A lot	4
Digital characteristics	50	5.68	0.09	A lot	2
1. Digital personal image	11	5.64	0.42	A lot	3
2. Digital function role	10	5.79	0.31	A lot	1
3. Digital performance result	15	5.62	0.39	A lot	4
4. Digital ethical practice	14	5.68	0.52	A lot	2
Total/average total	139	5.62	0.03	A lot	-

M, mean; SD, standard deviation.

not more than 1.50, and the Mdn was between 5.50-6.00, indicating that it was the most consistent, and the absolute value of the difference between the mode and the median was between 0.00-0.50. The digital skills dimension (4 aspects, 20 issues) found that the IQR was not more than 1.50, and the Mdn was between 5.00-6.00, indicating that it was the most consistent, and the absolute value of the difference between the mode and the median was between -0.25-0.00. The digital feature dimension (4 dimensions, 36 issues) found that the IQR was not more than 1.50, and the Mdn was between 6.00-6.00, indicating that it was the most consistent, and the absolute value of the difference between the mode and the median was between 0.00-0.00, as shown in Table 6.

4.3. Results of the Proposed Framework for the Essential Digital Workforce for the Provincial Offices in Thailand

Results were derived from the analysis of the key points from the consensus confirmation of conformity (Table 6), consisting of the overall components, the total amount of 3 dimensions, 14 aspects, and 61 issues, as shown in Fig. 3.

4.4. Additional Recommendations and Guidelines

4.4.1. Promoting Digital Work Management according to the Policy Plan

Suggestions of driving digital management according to the policies and operational plans of the Provincial Offices in Thailand in the future include: (1) increased or sufficient personnel support for digital workloads, (2) establishing a digital skills development framework for personnel, (3) promoting sufficient digital technical competency along with modern digital tools, and (4) raising awareness of adapting and paying attention to competency dimensions according to different contexts of personnel and organizations, as in the interview examples here:

> ...It is necessary to establish a framework for developing digital skills that will promote and support the use of digital technology in operations and the development of government work, and support the transformation of the public sector into a digital government…. (D001, interview, 18 March 2022)

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Table 6. Summary of the consensus of the essential competency framework required for the digital workforce of provincial offices in Thailand

Dimension	Number (issue)	Consensus					
		Mod.	Mdn	Mod.-Mdn	Q3	Q1	IQR
Digital literacy	28	6.00	5.88	0.13	6.25	4.84	1.41
1. Digital use	5	6.00	5.50	0.50	6.25	5.00	1.25
2. Digital understanding	3	6.00	6.00	0.00	6.25	5.00	1.25
3. Digitally applied creativity	4	6.00	5.75	0.25	6.25	5.00	1.25
4. Digitally using problem-solving tools	3	6.00	5.50	0.50	6.25	4.75	1.50
5. Digital transformation adapting	5	6.00	6.00	0.00	6.13	4.88	1.25
6. Digital organization management	8	6.00	6.00	0.00	6.25	5.00	1.25
Digital skill	20	6.00	5.63	0.38	6.25	4.83	1.42
1. Digital technology	5	6.00	6.00	0.00	6.25	5.00	1.25
2. Digital systematic calculation	4	5.00	5.25	-0.25	6.00	4.81	1.19
3. Digital service innovation	5	5.00	5.00	0.00	6.25	4.88	1.38
4. Digital programming	6	6.00	6.00	0.00	6.25	5.00	1.25
Digital characteristics	36	6.00	6.00	0.00	6.25	4.81	1.44
1. Digital personal image	9	6.00	6.00	0.00	6.25	4.75	1.50
2. Digital function role	9	6.00	6.00	0.00	6.13	5.00	1.13
3. Digital performance result	9	6.00	6.00	0.00	6.25	5.00	1.25
4. Digital ethical practice	9	6.00	6.00	0.00	6.25	5.00	1.25

Mod., mode; Mdn, median; Q, quartile; IQR, interquartile range.

> ...The 3D performance framework, regarding knowledge skills (abilities) and attributes, is still suitable for driving. The weights of the 14 sub-components may differ depending on the context of each organization... (C001, interview, 8 March 2022)

4.4.2. Guidelines for Promoting the Essential Competencies in the Future

As illustrated in Fig. 3, guidelines for driving the critical digital competencies of the workforce through the development of digital-specific technically assisted artificial intelligence for public sector organizations may include: (1) guidelines for establishing a framework for developing essential digital competencies that could promote and support the use of digital technology in work for all workforce levels equally, (2) guidelines for policy framework comprehensive digital implementation plans to support digital government transformation development platforms, (3) guidelines for driving the digital networking policy to develop the digital competencies needed to manage the digital workforce for the dynamic organization, and (4) guidelines for a systematic approach to developing essential competencies using the digital knowledge, skills, and feature dimensions for people development planning, technology, and digital management.

5. DISCUSSION

The results of the essential competency requirements for the digital workforce of the Provincial Offices in Thailand are as follows:

The findings provide a comprehensive overview of the competencies needed for digital literacy, emphasizing the necessity for clear, current, and timely knowledge. These competencies are crucial for responding innovatively to evolving technological demands and effectively understanding and managing complex digital data sets. This could be analyzed, adapted, and planned to be utilized dynamically and collaboratively in response to missions with expertise (Alaimo, 2022), which require finding the most appropriate model by taking advantage of skills and re-



Fig. 3. Essential competencies for the digital workforce for the Provincial Offices in Thailand.

sources of organizations through data generated by data-driven digital technologies (Björkdahl, 2020) focused on auditing optimization. The Provincial Offices in Thailand have responded by approaching an organizational model that exploits coherence and interdependence (Cennamo et al., 2020). This is an opportunity to innovate change in structure, process, and management models that enable organizations to adapt quickly and continuously (Cennamo et al., 2020; Hanelt et al., 2020; Lanzolla et al., 2020). Schallmo and Lohse (2020), along with Verhoef et al. (2021), posit that the application of digital technologies in the analysis and collection of data encompasses the generation of actionable information for assessment, decision-making, and the development of innovative digital business models. This process aids organizations in creating value and enhancing performance, encapsulating the concept of "Organization+Technology+Information." This concept is characterized by model innovation, value creation, and the emergence of new economic paradigms. Parallel to this, the professional development of librarians, as discussed by Ezeani et al. (2015), has facilitated their ability to design novel information resource formats for communities, thereby contributing to the advancement and stability of the librarianship career (Khan & Du, 2017;

Sivankalai, 2021; Venturella & Breland, 2019). An example of this evolution is the creation of e-learning communities, where an operating system, leveraging online knowledge resources, functions as an e-learning server. This system allows users to engage with libraries via the Internet, as illustrated by Cooke (2012), thereby expanding the scope and accessibility of library services.

It is imperative to possess competencies in specific professional skills, which involve integrating knowledge acquired from digital transformation to transition into the new digital paradigm that is both in demand and congruent with digital work. The Intellectual Property Rights Allocation Regime and Geopolitical Strategy have emerged as critical conditions for utilizing technology and digital information (Brem & Nylund, 2021; Lee, 2018; Petricevic & Teece, 2019). Producing and portable accumulation of big data for worldwide policymakers requires better infrastructure, interfaces, and storage (Otto & Jarke, 2019), along with a robust infrastructure to enable governance to create more value and distribute more widely (Jones & Tonetti, 2020). While having more accessible access to many platforms as a member leads to more creativity, it might encourage opportunistic behavior (Karhu & Ritala, 2021). Consequently, pursuing creative digital organizational innovations is essential (Cennamo & Santaló, 2019). The study by Popoola and Adedokun (2023) revealed that collective intelligence skills markedly influence the utilization of electronic library resources. Furthermore, librarians' attitudes towards technology underscore the importance of skills such as computational thinking in technology development, coding proficiency, and using technology as a tool tailored to local needs. Additionally, the necessity for technical language skills and the capability to bridge users with technology necessitates a comprehensive understanding of both domains (Cox, 2023).

As for the digital attributes dimension, there is a need for digital collaboration capabilities within the context of accuracy, fairness, and transparency in the digital ecosystem environment and within the digital workforce. The human involvement of behavioral needs, expectations, creativity in design, and the use of digital technology to solve problems and perform other tasks, might be at risk of being used as a customization tool according to the needs of the organization (Kellogg et al., 2020; Nørskov, 2022). Therefore, determining how to design digital technology that facilitates including a model of sustainable cultural use is an important management task. It has to be ensured that those technologies could enhance moral, social, and emotional skills to bring about valuable changes in practices and norms in the workplace (Ulhøi & Nørskov, 2021), while individual competencies depend on digitally promoting learning, engagement, and problem-solving (Belpaeme et al., 2018; Ford, 2015; Tennent et al., 2019; Traeger et al., 2020). Organizations must maintain equilibrium among structures, formats, and ecosystems shaped by design principles and processes stemming from digital technology. This balance is crucial to effectively harness the organization's existing knowledge, capabilities, and potential (Lanzolla et al., 2020; Maijanen & Virta, 2017). Such an approach fosters an awareness of the varying priorities that exist at different levels: personal (emotional), organizational (strategic), and geographic (regulatory). This awareness acknowledges the distinctiveness and significance of each level in the broader organizational context (Aarikka-Stenroos et al., 2021; Nylund et al., 2021). At the same time, library and related fields are beginning to show interest and study the services, changes, and application of technology in the metaverse era (Njoku et al., 2023). The metaverse is a newly created space built on various technologies, such as virtual reality, cloud computing, blockchain, and 5G (Kesselman & Esquivel, 2022). To develop smart libraries and provide intelligent and convenient public services (Sanji et al., 2022), it is generally recognized that smart librarians are the driving force behind the development of libraries and are representatives of the main components of smart libraries (Duncan, 2021).

However, developing measurable benchmarks should be considered role norms seeking the link between participatory processes, trust, and firm performance (Roy, 2022). Dynamic analysis, guidelines, rules, and interactions are necessary as organizations increasingly rely on technology. Therefore, there is a need to balance productivity and human well-being (Nørskov & Nørskov, 2020). As one clear example, AI is an extension of personal abilities and a potential replacement for human cognition, including increasing the creativity of individuals and teams (Amabile, 2019; Wang & Siau, 2019). Therefore, it affects employees' well-being and performance in digital work environments (Marsh et al., 2022). At the same time, the results confirm conformity as a unanimous consensus. This is an evaluation of data choices per the decision by a group of 10 primary informants who cooperated in identifying data according to reduced items. Consequently, the issues encapsulated within the essential competency framework for digital workforces were rendered more specific and lucidly delineated. This clarification aligns with the argument presented by Belton et al. (2021), who qualitatively exam-

ined data feedback issues. They raised concerns regarding whether pre-judgmental or selectively curated information poses an intellectual challenge, noting that the clarity of this challenge was previously ambiguous. The extent of this challenge depends on the interaction between many factors, including the amount of data (number and length of reasons and overall word count), complexity (variety of viewpoints, explanations, arguments, and types proposed), and the participants' expertise. The researcher often had to read other primary informants' responses and written rationale before reviewing them to make informed decisions with extreme accuracy (United Nations Educational, Scientific and Cultural Organization (UNESCO), 2019).

6. CONCLUSION

This research explored the essential competency framework for the digital workforce in Thailand's Provincial Offices. Utilizing a Delphi study, a rigorous consensus confirmation process was employed to achieve consensus on key issues. This process facilitated the prioritization of appropriateness in digital literacy across six aspects, digital skills encompassing four aspects, and digital characteristics also spanning four aspects. Consensus was established for 84 issues, concluding that 61 points are critical for constructing an effective competency framework for the digital workforce, enhancing their efficiency in utilizing digital technology as a labor-saving tool. Consequently, the findings of this study can inform the development of more thoughtful and practical program strategies. Furthermore, the identified essential competency framework for the digital workforce in this research can be adapted for broader coverage and policy adjustments as needed. This adaptability extends to planning, decision-making, implementation, evaluation, and future research endeavors. However, the group of primary informants in this study was relatively small. Suppose there are future studies with larger sample sizes. In that case, the findings of the performance outcomes required for the digital workforce can be most prominently demonstrated in a volatile technology environment, quickly and continuously in the digital world, and to make research more in-depth and different. Furthermore, this will result in guidelines to promote, develop and train specific digital techniques. It is essential to focus on applying the necessary competency frameworks for digital manpower to improve the curriculum of relevant digital-related courses, including digital technology, computer science, information science, and library science. These are professional fields that require the continuous development of digital competencies to create valuable and sustainable potential.

The combination of a digital workforce and the Delphi technique can be highly beneficial to libraries and library professionals in several ways. The following is an overview of how these two elements can contribute to their effectiveness:

6.1. Digital Workforce in Libraries

Automation: Libraries can leverage digital technologies to automate repetitive and mundane tasks, such as cataloging, inventory management, and circulation processes. This allows library professionals to focus on more strategic and value-added activities.

Enhanced access: Digital platforms and online catalogs enable libraries to provide greater accessibility to their collections, resources, and services. Users can search, request, and access materials remotely, expanding the reach of the library beyond physical boundaries.

Personalization: Digital tools can enable libraries to personalize user experiences by offering recommendations based on users' preferences and interests. This can enhance engagement and satisfaction among library patrons.

Data analysis: With a digital workforce, libraries can collect and analyze data on user behavior, resource utilization, and preferences. These insights can help librarians make informed decisions regarding collection development, resource allocation, and service improvements.

6.2. Delphi Technique for Decision Making

Expert consensus: The Delphi technique involves gathering input from a panel of experts through a structured and iterative process. Libraries can employ this technique to tap into the collective wisdom and knowledge of library professionals, researchers, and scholars for decision-making purposes.

Strategic planning: Libraries can use the Delphi technique to identify emerging trends, anticipate future challenges, and develop long-term strategic plans. The iterative nature of the technique allows for refining and validating ideas over multiple rounds, resulting in well-informed decisions.

Resource allocation: The Delphi technique can aid libraries in determining resource priorities and allocations. By engaging a diverse group of experts, libraries can assess the relative importance of different projects, initiatives, or services, leading to more efficient and effective use of available resources.

Policy development: Libraries often face complex issues and dilemmas requiring careful policy development. The Delphi technique facilitates structured discussions, helping library professionals reach consensus on policies and guidelines that align with user needs and organizational objectives.

Combining a digital workforce with the Delphi technique empowers libraries and library professionals to harness technology for automation, improved decision-making, enhanced user experiences, and optimized resource utilization. By leveraging these approaches, libraries can adapt to the evolving needs of their patrons and remain relevant in the digital age.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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APPENDIX

Interview Terminology Set 1 and Set 2 (Phase 1)

A digital workforce refers to individuals who work in computer-related positions within their respective career paths and have additional responsibilities as assigned by provincial offices in Thailand.

Digital technology refers to the tools and systemic environment of a new working format that serves as a central axis to drive collective potential through digital networks, without being restricted by location and time, for the purpose of sharing and leveraging mutual benefits.

The context of provincial offices refers to the current situation of provincial offices in Thailand, which includes the organizational structure, duties, and internal division of tasks within the government agencies under the decentralized administrative structure of the Ministry of Interior. It also encompasses the working environment, readiness, and adequacy of information and digital technology.

An internal organizational management platform refers to the comprehensive process of managing everything within an organization to support the transition to a digital format as outlined in the national digital development plan for the economy and society for the years 2018-2037. This platform includes the Back Office by Digital Default system, smart service systems, inter-service systems, the seamless integration of government agencies as a single organization, beneficial data disclosure systems, and learning systems within an open framework for the general public.

Necessary competencies refer to essential behavioral characteristics in the performance of digital workforce, resulting from learning, expertise, proficiency, and other personal attributes. These competencies contribute to outstanding job performance, creating value and benefits for both the organization and society. They include:

A. Digital competency dimensions, consisting of three aspects, including:

1) Digital Knowledge Dimension, consisting of 6 aspects:

(1) Digital Usage, which refers to technical proficiency in digital technologies and the ability to leverage expertise from devices and knowledge sources for maximum benefit.

(2) Digital Understanding, which entails comprehending content, roles, being aware, and responsible for intellectual property and effectively managing information using critical thinking for digital media assessment.

(3) Digital Creative Application, which involves the ability to use digital technologies as tools for content creation and efficiently adapt various communication methods.

(4) Digital Problem-Solving Tool Utilization, which involves evaluating products through diverse digital media and assessing the accuracy of information to successfully employ digital technologies in problem-solving.

(5) Digital Adaptation, which encompasses managing knowledge, attitudes, and skills necessary to identify information needs, digital technologies, and digital media of an organization.

(6) Digital Organizational Management, which involves managing knowledge, attitudes, and skills to connect digital technologies for communication, collaboration with others, networks, and online communities.

B. Digital Skills Dimension, comprising 4 aspects:

(1) Digital Technology Skills, which encompass the knowledge and utilization of digital technologies to facilitate digital work transformation aligned with the structure, context, and digital operations of an organization.

(2) Systematic Thinking, which involves a comprehensive understanding that connects theoretical concepts related to digital technologies and technical practices in the digital field. It leverages creative thinking to develop systematic software programs for the organization, based on academic expertise and systematic skills of digital workforce within the organization.

(3) Service Innovation, which entails creating content derived from new knowledge sources through diverse technologies and digital media. It enables widespread recognition and dissemination of content through online social platforms.

(4) Programming Skills, which refers to the ability of digital workforce in understanding the principles of programming that support the platform for internal organizational management. This leads to the implementation of online systems that benefit the overall organization in all sectors with efficiency and effectiveness.

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C. Digital Competency Dimensions, consisting of 4 aspects:

(1) Personal Image, which refers to competencies that exist within an individual and are challenging to observe and access. It arises from motivations, distinctive characteristics, and self-perception, and is visible through knowledge and skills that drive behaviors demonstrated in digital technology work.

(2) Roles and Responsibilities, which encompass the ability to work with various digital technologies and media securely, accurately, and efficiently.

(3) Work Performance, which involves communication of knowledge, attitudes, and skills through ethical online sharing tools, with an awareness of privacy and security.

(4) Ethical Work Practices, which entail an awareness of the positive and negative consequences in terms of knowledge, opinions, and necessary expertise regarding transparency, ethics, and laws related to digital technologies and diverse media.

Digital Technology Policies and Plans, according to the National Policy and Plan for Digital Development for Economy and Society, B.E. 2561-2580, consist of 2 aspects:

1. Current Platform Management Objectives: This involves setting goals for managing the existing platforms within an organization and establishing management objectives for all 6 platforms to align with the digital development plan for the economy and society, B.E. 2561-2580.

2. Digital Technology Implementation Plans: This includes incorporating the current platform management objectives and the management objectives for all 6 platforms into the digital development plan for the economy and society, B.E. 2561-2580, to create a short-term 4-year operational plan for digital technology work within the organization.

Interview for Research, Set 1 (Phase 1)

Essential Competencies for Digital Workforce of Provincial Office in Thailand: Using Delphi Technique

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Instructions: This interview is conducted to collect data from the first round of personnel in Phase 1. The objective is to study the digital competency needs of provincial offices in Thailand. The collected data will be used as a guideline to create the necessary competency framework for digital workforce in provincial offices in Thailand, as follows:

1. Opinions on the necessary competencies for performing digital technology-related tasks within the organization.

2. Other suggestions that support the development of necessary competencies for the digital workforce within the organization.

The researcher kindly requests your cooperation in providing truthful responses to all interview questions and sharing your opinions along with any additional suggestions based on your genuine knowledge. This will greatly contribute to the completeness and academic relevance of the study for future benefits.

Researcher

Opinions on the necessary competencies for performing digital technology-related tasks within the organization.

Instructions: Please provide your opinion on the competencies that are most essential for performing digital technology-related work within your organization, based on the most realistic assessment.

1. Competencies necessary for digital workforce.

1.1. What competencies do you think are necessary for digital workforce to perform in the following digital technology-related areas? Please provide reasoning to support your response. and list specific sub-competencies.

1) Digital Literacy: (1) Digital Use, (2) Digital Understanding, (3) Digital Applied Creativity, (4) Digitally Using Problem-solving Tools, (5) Digital Transformation Adapting, and (6) Digital Organization Management

2) Digital Skill: (1) Digital Technology, (2) Digital Systematic Calculation, (3) Digital Service Innovation, and (4)

Digital Programming
3) Digital Characteristics: (1) Digital Personal Image, (2) Digital Function Role, (3) Digital Performance Result, and (4) Digital Ethical Practice

1.2. What do you think are the essential competencies for individuals working in the digital technology field, specifically as digital assets in your organization? Which aspect do you consider the most important and why? Additionally, what specific qualities should they possess? (You can choose more than one aspect or all aspects, along with providing reasons and recommendations for those specific qualities.)

1) Digital Literacy
2) Digital Skills
3) Digital Characteristics

Other recommendations that support the development of essential competencies for digital workforce practitioners in the organization

Instructions: Please provide recommendations on the requirements needed to support the development of essential competencies for the digital workforce in your organization based on the most realistic needs.

The desired competencies for the digital workforce in an organization with the potential to drive and manage digital operations according to policies, action plans, or future development strategies are as follows. What are they and why are they important?

Research Interview Questionnaire Set 2 (Phase 1)

Essential Competencies for Digital Workforce of Provincial Office in Thailand: Using Delphi Technique

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Instructions: This interview questionnaire aims to gather information from a group of digital technology experts in Phase 1, with the objective of studying the necessary digital competencies for provincial offices in Thailand. The data collected will be used as a guideline for developing the essential competency framework for digital workforce in provincial offices across Thailand.

1. Opinion on the necessary competencies required for digital workforce performance on an internal management platform within an organization.
2. Recommendations and essential comments on the competencies of the digital workforce.

The researchers kindly request your input and interview responses to each question based on your truthful knowledge and opinions. Please provide additional suggestions with factual completeness for the benefit of academic purposes appropriately.

Researcher

Opinion on the necessary competencies required for digital workforce performance in digital work.

Instruction: Please provide your feedback on the necessary competencies required for actual and appropriate digital workforce for digital operation.

1. What do you think are the essential competencies required for the digital workforce to perform digital work and manage the following platforms? What specific important characteristics should they possess?

1) Back Office by Digital Default System
2) Smart Service System
3) Peer to Peer System
4) One Government System

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5) Open Data System
6) Massive Open Online Courses System (mooc)
7) In cases where there is no management based on the aforementioned six platform formats, but there is management related to digital technology within the organization, what specific characteristics are necessary?

Recommendations and essential feedback for digital workforce competency.

Instructions: Please provide recommendations and feedback regarding the necessary competencies for the digital workforce. This will serve as guidance in establishing the framework for developing essential competencies required for the digital workforce to be relevant in the future.

Do you wish to understand the competencies of a digital workforce within an organization, particularly those with the potential for driving and managing digital operations in line with policies and operational plans? Alternatively, are you interested in exploring strategies for fostering these necessary competencies in the future?

Sample Issues in Questionnaire Set 3 (Phase 2)

An assessment form on compliance and conformity represents my individual standpoint on the essential competencies related to the digital transformation of provincial government offices in Thailand.

Instructions: This assessment form is designed to collect data from both the personnel group and the group of digital technology experts in the second phase of the second interval. The objective is to study the level of agreement and conformity to the unique perspective of the issues within the necessary competency framework for the digital workforce of provincial offices in Thailand. The data will be used as a guideline for the development and improvement of the necessary competency framework for the digital workforce of provincial offices in Thailand, with the aim of effectively applying it towards the intended goals. It is divided into two sections as follows:

Section 1: Opinions on the conformity and alignment to the unique perspective of the issues within the necessary competency framework for the digital workforce of provincial offices in Thailand.

Section 2: Recommendations and feedback for the necessary competency framework for the digital workforce of provincial offices in Thailand.

The researchers kindly request that you, the information provider, mark the symbol "✓" in the square symbol "☐" for true statements. Please provide additional recommendations based on the truth to make them more complete for academic purposes and future benefits.

Researcher

Section 1: Opinions on the conformity and alignment to the unique perspective of the issues within the necessary competency framework for the digital workforce of provincial offices in Thailand.

The scoring criteria for each dimension/aspect/issue are as follows:

7 points=Very high, 6 points=High, 5 points=Moderately high, 4 points=Moderate, 3 points=Moderately low, 2 points=Low, 1 point=Very low.

Dimension/aspect/issue	Level of opinion						
	7	6	5	4	3	2	1
Digital Literacy							
1. Digital Use							
- Utilize digital tools to enhance productivity and solve problems.							
- Utilize digital technologies diversely and efficiently.							
- Apply digital technologies in work processes.							
- Utilize basic digital tools or applications for work purposes.							
- Utilize digital technology for communication and information sharing.							
- Apply, select, and utilize modern digital technologies to transform work processes and service delivery.							
- Utilize digital technology as formulas or functions for data calculation and prediction.							
- Utilize digital technology to support education, exploration, and research in work practices.							
- Utilize digital technology to integrate and adhere to digital work standards.							
- Utilize digital technology to design efficient and effective processes.							
- Utilize digital technology for planning, managing, and delivering diverse and appropriate services.							
- Utilize digital technology as network systems and software for work purposes.							
2. Digital Understanding							
- Understand digital comprehensively and holistically to drive organizational transformation in all aspects.							
- Understand laws, policies, and digital management standards.							
- Understand, control, and monitor compliance with policies and standards in digital management.							
- Understand the design and define the direction for organizational digital development.							
- Understand the management and administration of digital security in the use and provision of digital services.							
- Understand openness and embrace new digital advancements.							
- Understand search, analyze data, and assess the reliability of technology and digital data.							
- Understand responsibility and be aware of intellectual property when using digital media content.							
- Understand, adapt, and keep up with digital changes.							
- Understand digital literacy and apply it to problem-solving in working with technology.							
3. Digital Applied Creativity							
- Creatively utilize digital tools to solve encountered work problems.							
- Utilize various digital media with innovative technology applications according to the intended purposes of use.							
- Initiate and innovate the use of technology to support, plan, and transform digital strategies and projects within the organization.							
- Apply the integration of new media, online social media, and traditional communication technologies.							
- Creatively utilize digital data for decision-making based on situational and cultural contexts.							
- Apply digital technology to create a variety of efficient tools and work methods.							
4. Digitally Using Problem-solving Tools							
- Using limited digital tools to handle problem-solving in encountered tasks.							

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Dimension/aspect/issue	Level of opinion						
	7	6	5	4	3	2	1
- Wisely deciding to use digital tools that are suitable for the objectives and requirements.							
- Using digital tools to support collaborative work and fulfill roles and responsibilities.							
- Consistently review the correct and appropriate use of digital tools in the work.							
- Familiarize oneself with various digital tools and utilize them in tasks and problem-solving.							
- Utilize modern digital tools to effectively design and implement appropriate work process problem-solving.							
- Curiously explore and seek knowledge about new technology and cutting-edge digital tools to apply in work.							
5. Digital Transformation Adapting							
- Eagerly learn new things, show interest, and stay informed about digital advancements.							
- Adapt and survive in both the current and future digital world.							
- Creatively generate innovative breakthroughs that yield benefits ahead of time and sustainably develop them independently.							
- Be flexible and adapt to the diverse social, economic, and cultural changes in the digital world.							
- Select appropriate digital technologies to develop organizational management platforms and provide digital services.							
- Embrace change and listen to feedback from others in applying new digital technologies and resolving work-related issues.							
- Control and adhere to digital management standards to leverage enterprise-level digital technologies.							
- Understand, possess the mindset, and adhere to digital management standards with a responsible and ethical approach to embrace changes effectively in work.							
- Be ready to learn new digital technologies and apply them to work.							
6. Digital Organization Management							
- Drive digital transformation and have strategies to address challenges arising from the use of digital technologies in the organization.							
- Set proactive guidelines and leverage digital technologies to address problems promptly in both current and future circumstances.							
- Review and evaluate problem-solving efforts by utilizing digital technologies to track and monitor events.							
- Respond to feedback and anticipate potential future situations or digital-related work issues.							
- Digital technology techniques supporting role-based work execution, collaboration, and interagency service delivery in the public sector.							
- Search for reliable digital information, understand how to reference the data used for analysis, and make informed decisions.							
- Establish digital policies and directions in collaboration with the organization.							
- Understanding the principles of knowledge management, mindset, and methods of interacting with others through digital technology.							
- Knowledge management and talent development in organizations utilize technology in their work processes.							
- Motivating or leading individuals within the organization to accept and manage knowledge and the use of digital technology towards digital transformation.							

Dimension/aspect/issue	Level of opinion						
	7	6	5	4	3	2	1
- Striving to learn about digital organizational management and applying it in the form of digital work practices.							
- Generating new knowledge in the field of digital innovation and using it creatively to adapt to the changes in the digital world.							
Digital Skills							
1. Digital Technology							
- Introducing new-age technology to replace outdated technology.							
- Inventing innovations and applying them to existing or limited technologies.							
- Proposing new digital concepts for transforming into a digital organization.							
- Learning, analyzing, and presenting ideas by comparing existing digital concepts to newer and superior digital concepts.							
- Utilizing digital technology as a key component in collectively transforming the organization into a digital entity.							
- Transmitting and applying digital technology to generate positive outcomes or achieve organizational objectives.							
- Choosing from a diverse range of digital technologies that are flexible and suitable for digital work tasks.							
- Aligning digital work tasks with the structure, context, and digital operations of the organization.							
2. Digital Systematic Calculation							
- Anticipating positive outcomes and the impacts of digital utilization.							
- Analyzing and reporting issues encountered in digital usage.							
- Engaging in logical and computational analysis, and applying it extensively to address and solve problems, thereby benefiting the advancement of new digital knowledge.							
- Designing and calculating the system, structure, and workflow of digital aspects to be in the form of digital processes.							
- Developing systematic and efficient processes for analyzing, problem-solving, and decision-making in digital work.							
- Designing algorithms to solve problems in digital work.							
- Performing calculations and systematically designing digital work components with clear and comprehensive structures and well-defined steps.							
- Creating, developing, and applying digital programs in a systematic and proficient manner, aligned with expertise and mastery.							
- Utilizing a variety of digital programs, integrating and collaborating in work tasks, while applying them according to the organizational needs.							
3. Digital Service Innovation							
- Creating digital innovations that encompass convenience for service providers and recipients, reduce time constraints, and allow for seeking new knowledge.							
- Utilizing digital business processes in conjunction with digital knowledge management and communication to create ethically-driven digital service innovations.							
- Designing a process for generating new digital propositions and creating value in digital service delivery.							
- Designing a new digital service model that places the user at the center of the digital experience.							

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Dimension/aspect/issue	Level of opinion						
	7	6	5	4	3	2	1
- Creating and integrating diverse content with digital technologies to make it accessible, verifiable, and transparent.							
- Creating and fostering digital innovation to generate comprehensive and impactful digital service innovations, both directly and indirectly.							
- Designing and creatively developing new digital services that are suitable for the job and provide services in terms of both time and location.							
- Creating new digitally integrated content formats for managing digital knowledge and applying them through various digital media channels.							
- Utilizing new digital platforms to develop digital service innovations and disseminate them through online channels.							
4. Digital Programming							
- Understanding the logic and workflow of coding commands and programs.							
- Writing steps and programs for developers to create new work or improve existing work in a new system.							
- Using computer language to define data structures and specify the step-by-step procedures used to solve problems according to the designed requirements accurately and appropriately.							
- Write and understand the fundamentals of programming.							
- Design and develop programs using modern computer languages that are suitable for digital tools.							
- Develop programs that can be applied according to the objectives of the work and expand the capabilities of using digital technology to operate according to the designed processes.							
- Develop programs that support organizational management platforms, leading to efficient online dissemination for overall effectiveness.							
Digital Characteristics							
1. Digital Personal Image							
- Provide assistance, support, and encouragement to personnel in addressing digital challenges.							
- Assist, promote, and support collaborative problem-solving in the digital realm.							
- Polite, well-mannered, with good interpersonal skills, capable of communicating effectively with individuals both within and outside the organization.							
- Listen to others' opinions from all perspectives and be open to information from all dimensions.							
- Differentiate, select relevant data sets, and analyze the data.							
- Learn, create, and take responsibility for digital technology.							
- Recognize the importance of digital technology and understand the concept of being a digital organization.							
- Work with purpose and achieve success using digital technology.							
- Conduct activities as routine tasks using digital technology.							
- Balance life in the digital era by utilizing modern technologies.							
- Reliability in providing digital services.							
2. Digital Function Role							
- Conducting digital work that aligns clearly with digital-specific skills.							
- Clearly delineating roles and responsibilities in digital work.							
- Supervising, monitoring, and overseeing the usage of digital work for managers, colleagues, and system users.							

Dimension/aspect/issue	Level of opinion						
	7	6	5	4	3	2	1
- Gathering up-to-date and fresh data to regularly formulate and maintain policies.							
- Thinking, analyzing, and considering the appropriate and up-to-date implementation of digital work policy.							
- Continuously improve and develop digital work policies to keep up with ever-changing technologies.							
- Learn, innovate, and utilize digital and media technologies securely, accurately, and efficiently.							
- Take responsibility for actions and activities that contribute to achieving one's own role and objectives.							
- Understand and apply knowledge to perform digital-related activities in accordance with assigned responsibilities.							
- Manage data of modern technologies and communicate in digital formats that facilitate outcome-driven service delivery.							
3. Digital Performance Result							
- Perform tasks and solve digital-related issues proficiently.							
- Execute digital tasks swiftly, minimize errors, and gain confidence in the work.							
- Resolve digital work issues promptly and efficiently.							
- Identify options and make effective decisions in digital work.							
- Manage digital work and time effectively.							
- Create a balance in life and digital work.							
- Understand the process of work and service in the digital field.							
- Utilize technology and efficiently search for information on using modern technologies.							
- Evaluate risks and plan for unexpected occurrences in digital work.							
- Communicate knowledge and attitudes through online technology sharing effectively.							
- Be aware of privacy and security in performing digital tasks efficiently and responsibly.							
- Create positive outcomes in digital work that contribute positively to the goals or plans of the organization.							
- Working in digital field according to necessary roles and responsibilities, must achieve results that align or promote the achievement of organization's goals or plans.							
- A positive attitude towards using digital technology in work, having knowledge of the selected technology, and selecting digital technology that is appropriate for the job characteristics.							
- Performing tasks by applying technology and digital management to achieve the set goals.							
4. Digital Ethical Practice							
- Accepting mistakes and embracing digital changes.							
- Being trusted and relied upon by digital service customers.							
- Utilizing high-value digital skills to maximize efficiency in digital work.							
- Applying standards, criteria, best practices, digital laws, and relevant laws to solve problems arising from technology use.							
- Disclosing information and not concealing errors in reporting digital work data according to the facts that have occurred.							
- Utilize risk management plans to assess the digital situation within the organization to prevent reporting data in a manner that does not align with the analysis results.							

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Dimension/aspect/issue	Level of opinion						
	7	6	5	4	3	2	1
- Evaluate digital work risks in conjunction with ethics and morality.							
- Be aware of the positive and negative impacts of using their own digital knowledge and skills.							
- Express opinions in accordance with ethical and legal standards in digital technology, consistent with digital governance principles and best practices.							
- Understand and be able to work in accordance with the digital ethics and overall organization's guidelines in the digital field.							
- Using digital technology while considering the impact that may arise from the operation, correctly and appropriately.							
- Choose to use digital technology wisely, appropriately, and for the benefit of oneself, the organization, and society with ethics.							
- Differentiate ethical and legal issues related to new or digital technology.							
- Perform digital work transparently without risking unethical or illegal actions.							

Section 2: Recommendations and feedback for the necessary competency framework for the digital workforce of provincial offices in Thailand.

Instructions: Please provide suggestions and comments on the necessary competencies for digital workforce as a guideline for developing appropriate competency frameworks for digital workforce in the future.

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One Hundred Scopus Citations to a Non-Scopus Indexed Article: A Case Study

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ABSTRACT

Receiving 100 citations from indexed journals is not a common occurrence, although it does happen very rarely, and it is even more uncommon for a non-indexed article. Given this, the purpose of this present study is to perform a bibliometric analysis of 100 cited Scopus articles to a non-Scopus indexed article, using a case study of the article titled "Authorship trends and collaboration pattern in the marine sciences literature: A scientometric study" which was published by Elango and Rajendran in the *International Journal of Information Dissemination and Technology* in 2012. On October 15, 2022, the Scopus database was searched with the article title in the references field, and the resulting bibliographic data was exported as a comma-separated values file. The tools utilized for this analysis were ScientoPy, the Bibliometrix R Package, and VOSviewer. Based on the findings, most of the cited articles were published within the last three years, and international researchers have given more recognition compared to Indian researchers. The most popular topics were found to be bibliometrics, bibliometric analysis, and bibliometrix. The fact that all 100 cited articles were published across various subject disciplines used by Scopus to categorise sources demonstrates how well-established the citing article is within the scientific community.

Keywords: bibliometrics, hundred citations, single-article, highly-cited articles, Scopus, sleeping beauty

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1. INTRODUCTION

Citation counts are now utilized as a proxy for assessing the quantity and quality of published articles (Nieminen et al., 2006). Measures of citation impact, such as h-index and journal impact factor (Garfield, 1972; Hirsch, 2005; Waltman, 2016), gauge the influence of scientific publications by analysing the citations they have received. Although there exist some critics of these indicators (Koltun & Hafner, 2021; Seglen, 1997), they are still commonly employed for research evaluation purposes (Wang et al., 2022). Since they demonstrate how a publication has incorporated the contents of other publications (research findings, other people's thoughts, etc.), citation counts or the number of citations are employed in research evaluation as an indication of research impact (Bornmann et al., 2008). By tallying the number of times an article is cited in other works, citation analysis determines the impact of an author's publications. In relation to this, Mammola et al. (2021) discovered that citing papers with a high impact factor enhances the number of citations.

1.1. Proportion of Highly Cited Papers

As per previous studies, only a minor percentage of articles or publications have received 100 or more citations. For example, Indian publications in orthopaedics accounted for 1.11% (Vaishya et al., 2022), Indian publications accounted for 0.56% (Elango & Ho, 2017), tribology research publications accounted for 0.77% (Elango & Ho, 2018), publications on obsessive compulsive disorder accounted for 4.49% (Grover & Gupta, 2022), papers on cyber security accounted for 0.53% (Dhawan et al., 2021), papers in the category of information science and library science accounted for 0.18% (Ivanović & Ho, 2016), papers in the category of education and educational research accounted for 0.53% (Ivanović & Ho, 2019), and papers in the category of horticulture accounted for 0.94% (Kolle et al., 2017), regardless of the publication year.

The results of a search for randomly chosen journals in the Scopus database were utilized to determine the percentage of highly cited papers with 100 or more citations. These journals are presented in Table 1. The findings reveal that the proportion of highly cited papers varies from 0.28% to 5% for the selected journals.

1.2. Research Questions

The reputation of a scientific article within the scientific community can be determined by the number of citations it has received. In the case of a non-indexed article, reputation is more recognized by the international scientific community. In this context, the purpose of this study is to analyse the nuances of an article by Elango and Rajendran (2012) (referred to as the "citing article") that is not indexed in Scopus but has received 100 or more citations. The study aims to answer the following specific questions:

- What is the temporal evolution of the cited articles?
- Who are the top authors among the cited articles?
- What are the top countries among the cited articles?
- Are there any common themes among the cited articles?
- What is the distribution of cited articles across subject disciplines?

In 2012, the authors of the citing article "Authorship trends and collaboration pattern in the marine sciences literature: A scientometric study" published it in the *International Journal of Information Dissemination and Technology*. The study utilized data collected from the *Indian Journal of Marine Sciences* from 2001 to 2010 to examine trends in authorship and collaboration. Various scientometric

Table 1. Number of highly cited papers (TC≥100) in selected journals

Sl.	Journal	ISSN	TP (as on 11.11.2022)	Publication period	HCP (%)
1	*Scientometrics*	0138-9130	6,871	1978-2022	260 (3.78)
2	*Journal of Informetrics*	1751-1577	1,238	2007-2022	62 (5.0)
3	*Research Evaluation*	0958-2029	863	1991-2022	19 (2.2)
4	*Journal of Documentation*	0022-0418	2,431	1945-2022	71 (2.92)
5	*Journal of the Association for Information Science and Technology*	2330-1635	1,406	2014-2022	32 (2.27)
6	*Publications*	2304-6775	351	2013-2022	1 (0.28)

TC, total citations; TP, total papers; HCP, highly cited papers.

metric tools, such as the collaboration index (CI), collaboration co-efficient, and dominance factor, were employed to analyse the data. The study also investigated the applicability of Lotka's law. Additionally, the study provided comprehensive information on the calculation of the CI, which is widely acknowledged by researchers (Alhawari et al., 2021; Bragg et al., 2022; Campra et al., 2022; Koseoglu, 2016; Secinaro et al., 2020; Xu et al., 2022).

1.3. Modified Collaboration Index

Previously, the CI was computed by taking into account all the authors and publications, including those with single-authors. However, the study conducted by Elango and Rajendran (2012) focused on determining the total number of authors who contributed to articles with multiple authors, as well as the total number of multi-authored articles. This approach was proposed to address some drawbacks in the previous method.

Collaboration Index (CI)=

$$\frac{\text{Total number of authors of multi–authored articles}}{\text{Total number of multi–authored articles}}$$

However, the above method also has some drawbacks. To illustrate, the following scenario may be considered:

- Article1 - Author1, Author2
- Article2 - Author2, Author1

In this example, there are two articles and two distinct authors contributing to them. Despite there being four authorships in total, the existing version of the CI (i.e. total number of authors divided by total number of articles) would yield a value of 1. In light of this, the study introduced a modified version of the CI (MCI), as follows:

Modified Collaboration Index (MCI)=

$$\frac{\text{Total number of authorships of multi–authored articles}}{\text{Total number of multi–authored articles}}$$

According to the modified version, the CI is computed by dividing the total number of authorships by the total number of multi-authored articles, resulting in a value of 2. In comparison to the previous version, the modified version produces a value that is twice as high.

2. DATA AND METHODS

The title of the citing article "Authorship trends and collaboration pattern in the marine sciences literature" was entered into the references field of the Scopus database in order to conduct a search. The search yielded 100 records, which are referred to as "cited articles." This search was conducted on October 15, 2022 (Fig. 1). The retrieved bibliographic records were then downloaded for further analysis. Various software tools, including Bibliometrix R Package (K-Synth Srl, Naples, Italy), VOSviewer, (Center for Science and Technology Studies, Leiden University, Leiden, Netherlands) and ScientoPy (University of Cauca, Popayán, Colombia), were utilized for this purpose.

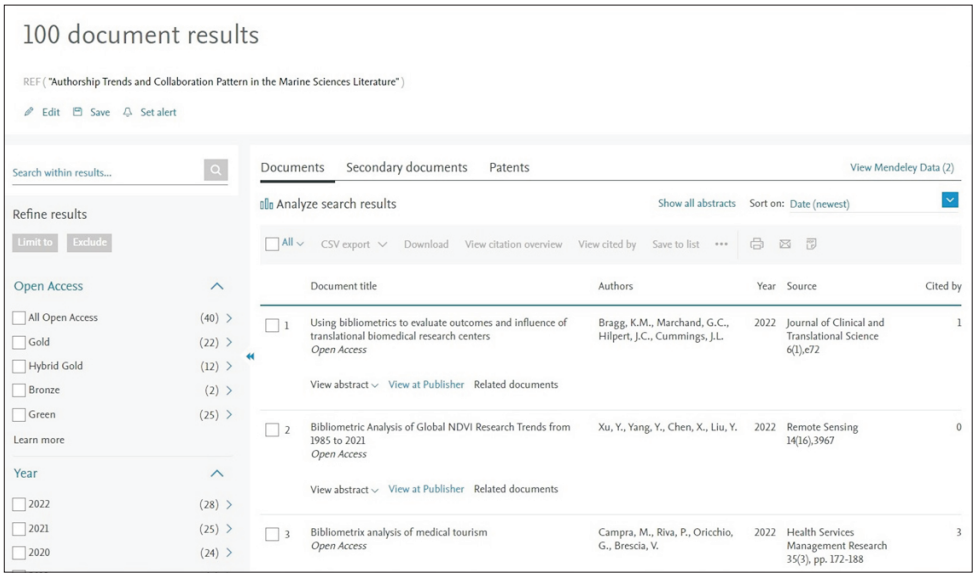


Fig. 1. Search results.

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3. RESULTS AND DISCUSSION

Table 2 presents the general information of 100 cited articles that were published between 2013 and 2022 (up to October 15, 2022). The data reveals that citations for the citing article began to accumulate in the year following its publication. These 100 cited articles were published in 69 different sources, with 67 of them scientific journals. Among the 100 cited articles, 71 have received at least one citation, while the remaining 29 have not yet received any. In comparison to other fields, the average number of citations for these articles is an impressive 8.77 (Elango et al., 2023; Niknejad et al., 2021).

The authors included three times the number of keywords as there were articles. Additionally, when compared to other subject areas, the number of articles (n=17) authored by single authors is relatively low (Arias-Chávez et al., 2022). The CI, which takes into account the authors, is calculated to be 3.19, surpassing several others fields (Arias-Chávez et al., 2022; Bashir, 2022; Campra et al., 2022; Di Cosmo et al., 2021; García-León et al., 2021). On average, each article has three authors (3.13) and CI is calculated to be 3.19. However, when accounting for authorships, the MCI is determined to be 3.57, which is 12% higher than the existing method.

The following explanation provides details on how to compute the MCI using the results obtained from Bibliometrix.

Table 2. Descriptive information of 100 cited articles

Description	Numbers
Timespan	2013-2022
Sources (journals and books)	69
Articles	100
Average citations per articles	8.77
References	6,413
Keywords plus	375
Author's keywords	338
Authors	277
Author appearances	313
Authors of single-authored documents	12
Authors of multi-authored documents	265
Single-authored documents	17
Collaboration index	3.19
Modified collaboration index	3.57

$$\text{Modified Collaboration Index (MCI)} = \frac{(\text{Author appearances}) - (\text{single-authored documents})}{(\text{Total documents}) - (\text{single-authored documents})}$$

The various document types from the 100 cited articles are shown in Fig. 2, illustrating that the majority of the studies were published as articles. It is not unexpected that articles are frequently chosen as the preferred document type for bibliometric OR scientometric analyses (Mooghali et al., 2011; Patra et al., 2006). Only two studies were published as book chapters, while 19 investigations were published as reviews. The remaining studies, excluding the book chapters, were published in 67 different journals.

Fig. 3 illustrates the annual trend of cited articles, encompassing a period of nine years from 2013 to 2022 (up until October 15, 2022). Following its publication in 2012, the citing article started to accumulated citations in 2013. The majority of the cited articles, approximately three-fourths, were published within the most recent three-year span from 2020 to 2022. The remaining articles were pub-

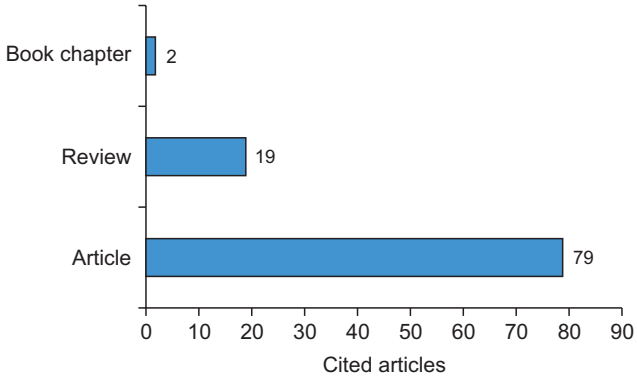


Fig. 2. Document types of 100 cited articles.

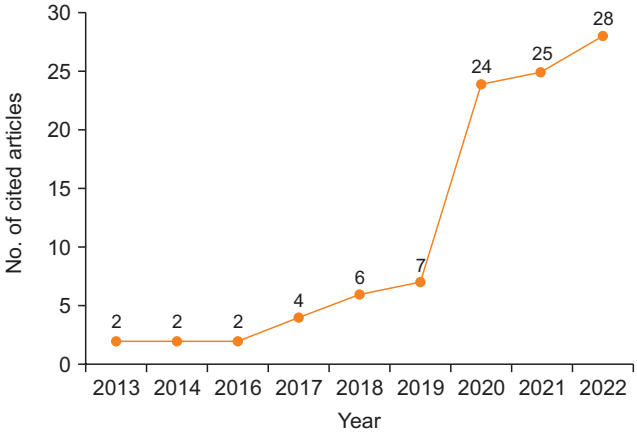


Fig. 3. Yearly trend of 100 cited articles.

lished over a duration of six years. As a result, the citing article can be referred to as a "sleeping beauty" (Song et al., 2018; van Raan, 2004).

Fig. 4 illustrates the top 10 authors of the 100 cited articles, along with the corresponding percentage of articles published in the most recent last two years, specifically 2021 and 2022. These distinguished authors have cited articles ranging from 2 and 9. With the exception of the author of the citing article, all other authors hail from different countries, exemplifying the international recognition of the article over its nation recognition. Notably, authors Köseoglu and King originate from Hong Kong, Mostafa is from Kuwait, Brescia, Calandra, and Secinaro are from Italy, Yildiz is from Australia, Zhang is from China, and Palacios is from Portugal. It is worth mentioning that authors Mostafa and Palacios have cited this citing article in five and two articles, respectively, all of which were published within the last two years. Following closely behind, Brescia cited this article in three-fourths of the articles, signifying the frequent citation of this article by these authors in recent years.

The authors of the 100 cited articles hailed from 35 different countries. Fig. 5 displays the leading 10 countries of origin of authors of these 100 cited articles, and these particular countries contributed articles ranging from between 4 to 25. Out of the 100 cited articles, only 25 were from India, which is the country of origin for the authors of the citing article. This clearly indicates that the article was highly esteemed within the international scientific community. Among these top 10 countries mentioned, Italy, the United Kingdom, the United States, and China were also recognized as top contributors to scientific production in 2021 (Elango, 2022). It can be observed that the citing article has garnered less attention from Indian authors, while attracting increased attention from the international scientific community. For example, more than 80% of articles by Italy, Kuwait, and Malaysia were

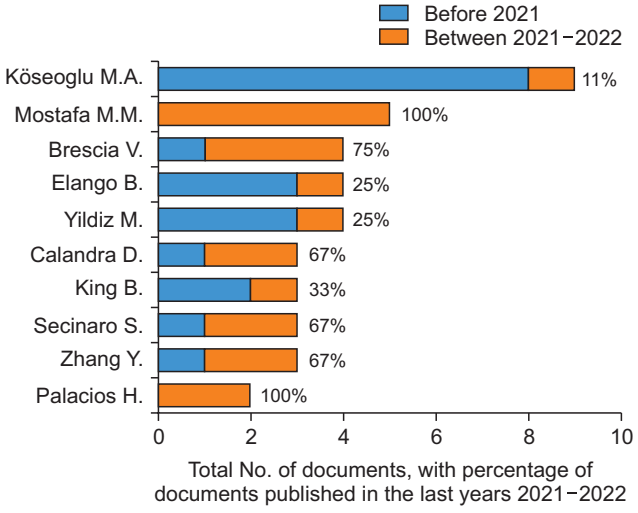


Fig. 4. Top authors of the cited articles.

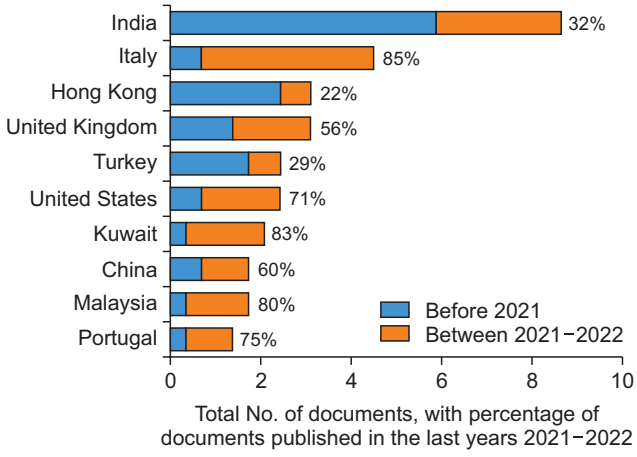


Fig. 5. Top countries of authors of cited articles.

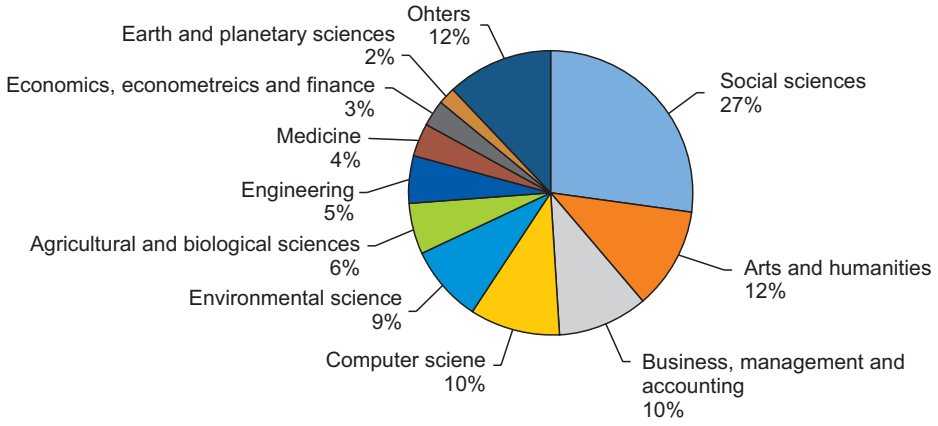


Fig. 6. Distribution of subject areas of 100 cited articles.

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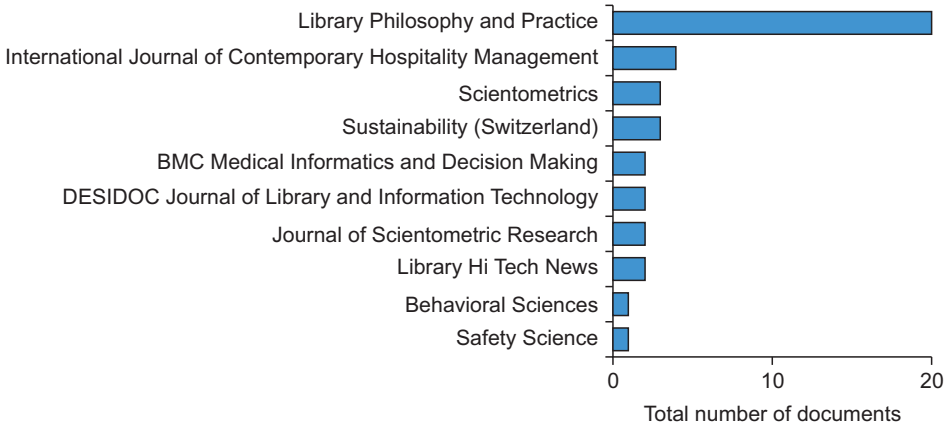


Fig. 7. Top journals of 100 cited articles.

published within the last two years, in comparison to only 32% by India.

The Scopus database contains 23 different subject-related sources where the 100 cited articles were discovered (Fig. 6). Out of the 27 subject disciplines used by Scopus to classify sources, only health professionals, immunology & microbiology, nursing, and pharmacology, toxicology & pharmaceutics have no cited articles. The majority of the cited articles were published in sources belonging to the disciplines of social sciences, arts & humanities, business management & accounting, computer science, and environmental science. This demonstrates that the article is being utilized as a resource in a wide range of disciplines.

Fig. 7 illustrates the top 10 journals, collectively responsible for publishing 40% of the 100 cited articles. Among these journals, six possess an impact factor for the year 2021, ranging from 2.286 (*Behavioural Sciences*) to 9.321 (*International Journal of Contemporary Hospitality Management*). While two of these journals are included in the Emerging Source Citation Index, they have yet to acquire an impact factor. This outcome serves as a testament to the exceptional quality of the cited articles. Unfortunately, *Library Philosophy and Practice*, one of the aforementioned ten journals, has been excluded from Scopus coverage due to concerns with its publication practices.

The word cloud shown in Fig. 8 presents the top 50 keywords used by the authors in the 100 cited articles. The size of the keyword or phrase is inversely related to the number of articles it appears in (Ruiz-Rosero et al., 2019). The analysis reveals that the keyword bibliometrics, authorship pattern, co-authorship, and social network analysis are particularly prevalent among the cited articles. Additionally, Fig. 9 provides an evolution plot of the top 10 author keywords, allowing us to examine their temporal patterns. The panel on the right side illustrates the average growth rate in relation to the proportion of articles published in the recent two years, while the panel on the left side displays the accumulative number of articles over the years. From the figure, it is evident that among the 100 cited articles, the most popular keywords are *bibliometrics*, *bibliometric analysis*, and *bibliometrix*.



Fig. 8. Word cloud of author keywords of cited articles.

The structure of a given subject is reflected in the connections between nodes (such as authors, papers, and journals) in a citation analysis network, and the edges can be interpreted in various ways depending on the network type, including co-citation, bibliometric coupling, and direct citation (Aria & Cuccurullo, 2017). Consequently, a co-citation network map of cited sources has been generated in VOSviewer to gain insight into the prominent sources among the 100 cited articles. The analysis focuses on cited sources, and out of 3,385 sources, 63 sources have been selected based on a threshold value of at least 10 citations per source. The resulting network map reveals 7 clusters (Fig 10). It is challenging to assign a specific subject area to the clusters since the cited journals belong

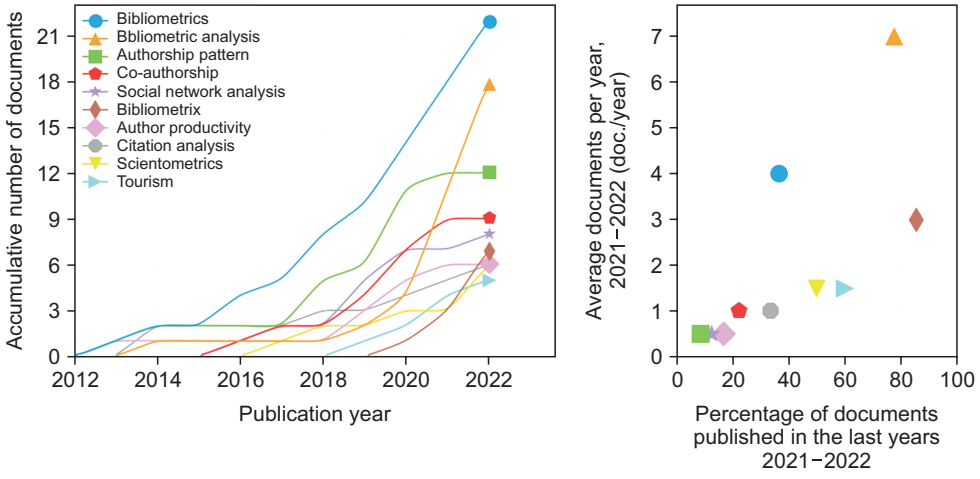


Fig. 9. Evolution plot of top 10 author keywords of 100 cited articles.

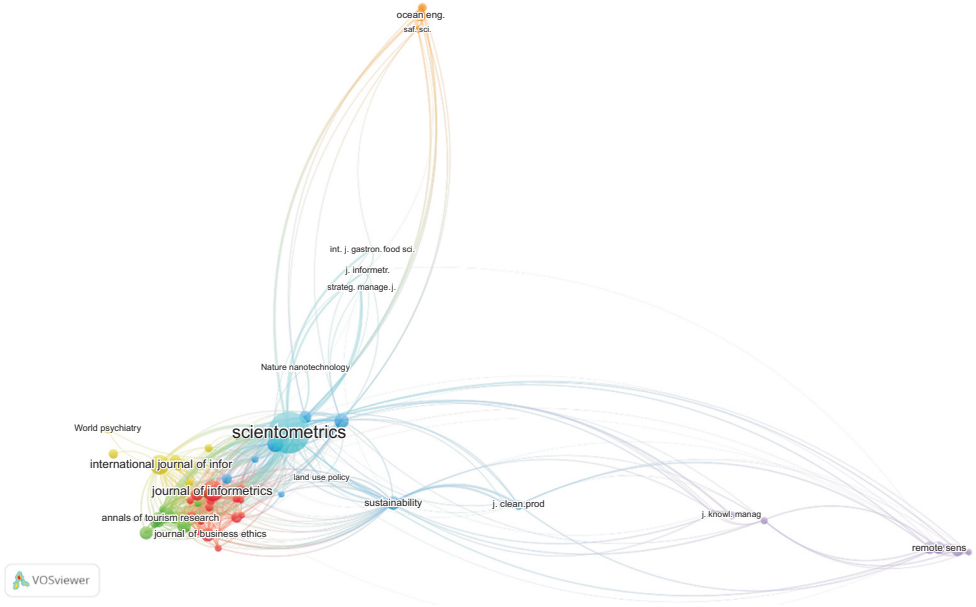


Fig. 10. Co-citation network of sources of 100 cited articles (unit of analysis= cited sources; minimum number of citations of a source=10).

to various subject areas. However, the most influential sources are *Scientometrics* and the *Journal of Informetrics*: Both of these journals were listed among the top 25 influential journals in the field of bibliometrics (Martín-Martín et al., 2018).

Author co-citation analysis, an important technique in bibliometrics, involves counting how many times an author's work is cited by another author in the references of citing publications. This technique is used to detect, analyse, and visualize the intellectual structure of a dataset (Bayer et al., 1990). To explore the prominent authors among the 100 cited articles, a co-citation network map of cited authors was generated using VOSviewer. The unit of analysis in this map is cited authors, and out of the 12,068 authors, 30 were selected based on a threshold value of at least 20 citations. The resulting network map reveals 4 clusters (Fig. 11). The largest network, represented by the colour red, includes the authors van Eck and Waltman, who developed the VOSviewer (van Eck & Waltman, 2010). The next significant cluster, represented by the colour green, consists of pioneers in the field of bibliometrics, like Leydesdorff and Glanzel. The blue cluster comprises the developers of Bibliometrix (Aria & Cuccurullo, 2017) and SciMAT (Cobo et al., 2012). Among these authors, Glanzel, Leydesdorff, and Garfield were identified as among the top 25 influential authors in the field of bibliometrics (Martín-Martín et al., 2018).

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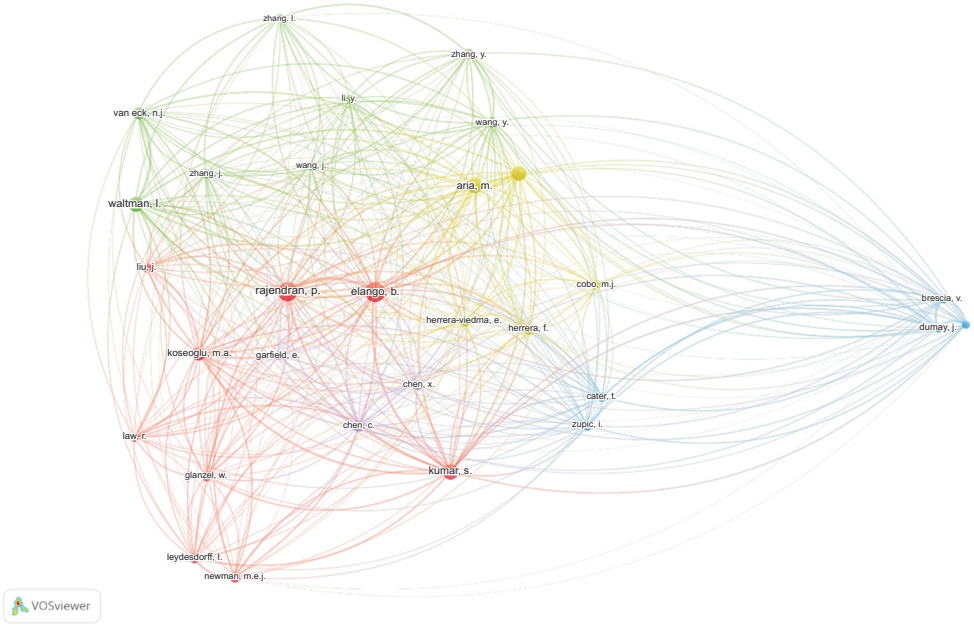


Fig. 11. Co-citation network of authors of 100 cited articles (unit of analysis= cited authors; minimum number of citations of an author=20).

4. MERITS AND DEMIERTS OF THE PROPOSED MCI

The current version of the CI possesses some limitations, and this study has proposed a MCI, which has the following advantages:

- It is easy to calculate.
- It can be employed to evaluate the level of collaboration among a group of authors on a particular dataset.
- It can be applied to any dataset type. For example, it can be used to compute for various document types, a specific author, institution, and country, a particular journal, and so on.

Undeniably, it has the following disadvantage:

- The author positions are not taken into account: for instance, whether they are the first, last, or corresponding author.

5. CONCLUSION

The citing article "Authorship trends and collaboration pattern in the marine sciences literature: A scientometric study" published by Elango and Rajendran in the *International Journal of Information Dissemination and Technology* in 2012, is used as a case study to demonstrate the results of a bibliometric analysis of 100 cited Scopus articles to a non-Scopus indexed article (Elango & Rajendran, 2012). This study yields some interesting facts. Receiving 100 citations from Scopus indexed articles by a Scopus-indexed article as well as a non-indexed article is highly reputable among the scientific community. Because the majority of the cited articles were published during the last three years, the results demonstrate that the citing article is a 'sleeping beauty.' The fact that three-fourths of the cited articles were authored by authors outside India demonstrates how well-recognized the citing article is on a global scale. The three most prominent themes among the 100 cited articles were bibliometrics, bibliometric analysis, and bibliometrix. The top 10 journals that published the 100 cited articles published 40% of the cited articles, and the scientific community worldwide is aware of all 10 journals. To summarise, regardless of the journal's indexing, the scientific community will recognize a publication that includes fascinating and significant material.

The results of this study are specifically constrained by the fact that they are based entirely on the 100 cited articles of the chosen citing article.

CONFLICTS OF INTEREST

The author of this study is one of the authors of citing article.

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Social Media Stickiness in the Z Generation: A Study Based on the Uses and Gratifications Theory

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ABSTRACT

The purpose of this study is to investigate how uses and gratifications motivations increase social media stickiness, with a special focus on media engagement as a key mediator. Data were gathered via a survey questionnaire from Bangladeshi Z Generation social media users, which was quantitative in nature. For the analysis of 258 survey samples, structural equation modeling methodology was used. The results show that social media engagement and social media stickiness are positively impacted by uses and gratifications motivations such as social interaction, information, convenience, and entertainment. The study also found evidence of a relationship between uses and gratification motivations and social media stickiness, which is also mediated by emotional attachment. Understanding the motivations and gratifications sought by Z Generation users on social media platforms can help design strategies to enhance engagement and loyalty, ultimately leading to improved user retention and platform success. By identifying and addressing the specific needs and desires of the Z Generation, social media platforms can tailor their features, content, and user experiences to foster a stronger sense of connection and satisfaction, resulting in increased user engagement and prolonged usage.

Keywords: uses and gratifications motivations, emotional attachment, social presence, social media stickiness

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1. INTRODUCTION

Social media has become an integral part of modern society, without which nothing can be imagined today (Cheung et al., 2022). It has revolutionized the way individuals, particularly the Z Generation, communicate, entertain, share information, and interact with the world. The Z Generation, also known as Generation Z or Gen Z, refers to individuals born between the mid-1990s and the early 2010s. This generation has grown up in an era dominated by social media, where platforms like Facebook, Instagram, Snapchat, Twitter, and TikTok have become an integral part of their daily lives (Ortiz et al., 2023). The significance of social media is apparent in numerous facets of personal, professional, and social existence. The majority of these social media platforms provide users with the chance to introduce others and link them to both current and potential social network members (Marjerison et al., 2022). Social media users seek gratifications such as social interaction, entertainment, information, and convenience. Understanding and addressing social media user gratification is essential for designing effective platforms, optimizing user experiences, fostering engagement, and ensuring the long-term success and sustainability of social media platforms (Habes et al., 2022). By fulfilling user needs and motivations through gratifications, platforms can create valuable and meaningful interactions that keep users engaged, satisfied, and loyal. Knowledge about social media users' gratification is crucial for understanding the motivations and behaviors of individuals in their engagement and 'stickiness' with social media platforms (Silveira et al., 2022); so, there is a need to understand the factors that contribute to the continuous usage intention of social media platforms specifically for the Z Generation.

Existing research has explored the uses and gratifications of social media across different age groups (Bucknell Bossen & Kottasz, 2020; Hossain et al., 2019; Ibáñez-Sánchez et al., 2022), but there is limited empirical evidence focusing specifically on the Z Generation. Understanding the unique motivations and engagement patterns of this generation can provide valuable insights into their social media behaviors and preferences. Additionally, while studies have investigated social media addiction and excessive use among young individuals (Fauzi et al., 2020), there is a need to understand the underlying gratifications and psychological factors that drive sustained engagement with social media platforms among the Z Generation. By examining the relationship between the uses and gratifications theory and social media stickiness, researchers can gain a better understanding of the mechanisms behind the Z Generation's continuous use of social media platforms. Understanding this mediating relationship can help platform developers and marketers design strategies to enhance engagement, align gratifications with user motivations, and ultimately promote long-term user stickiness and platform success (Moon et al., 2022).

Several empirical studies demonstrate a considerable positive correlation between uses and gratifications motivations, and social media stickiness (Falgoust et al., 2022; Hossain et al., 2019; Qin, 2020). As far as we know, no studies use social media engagement as a mediator in relation between uses and gratifications motivations, and social media stickiness.

Recognizing the research gap, this study uses social media engagement as a mediator. Therefore, the purpose of this study is to investigate how uses and gratifications motivations increase social media stickiness within the Z Generation, with a special focus on media engagement as a key mediator. By investigating the motivations and gratifications sought by the Z Generation on social media platforms, we can gain insights into the factors that contribute to their continued engagement and usage. Social media platforms strive to meet users' needs and desires by offering gratifications that fulfill their motivations. When users derive gratification from social media use, it leads to increased satisfaction, which in turn promotes higher engagement levels. Gratification-oriented experiences keep users invested and interested in using social media platforms, leading to sustained and continuous usage (Mao & Hovick, 2022). Considering these factors, we put forward two research questions (RQs):

> RQ1: What are the main gratifications obtained from using social media, and how do they encourage Z Generation users to stick with that social media?
> RQ2: Whether and to what extent does media engagement mediate the relationship between gratifications and stickiness?

The findings of this study will advance knowledge in multiple ways on how people use social media, with a special emphasis on the Z Generation. First, it will provide insights into the motivational factors that drive their engagement with social media platforms, shedding light on the unique dynamics of this generation's relationship with social media. By concentrating on this particular generation, the research sheds light on a special group that has developed in the digital age and has distinctive views and

expectations about social media. Second, our research will provide a greater understanding of the underpinning incentives and gratifications that underlie the Z Generation's engagement with social media. Third, our study will give accurate insight into the particular motives that drive Generation Z to be active on social media platforms by evaluating the important aspects that affect social media stickiness in this generation. Fourth, these understandings will be valuable for researchers, practitioners, educators, and policymakers seeking to effectively engage with and support the Z Generation in the digital age. Fifth, marketers may modify their strategies to successfully engage and keep younger consumers by knowing the elements that increase social media stickiness. Finally, platform designers can apply these insights to produce user interfaces that cater to Generation Z's desires and requirements, making social media platforms more enticing and interesting.

2. THEORETICAL FRAMEWORK

The researcher used Uses and Gratifications Theory as the conceptual background of this study. In the late 1940s, the uses and gratification approach to media use first appeared. Uses and Gratification Theory is a key sociological theory that explains why and how individuals choose certain media outlets to suit their needs (Marjerison et al., 2022). In Uses and Gratification Theory, Katz sees all audiences as active participants who always have a desire to be satisfied (Habes et al., 2022). The theory suggests that individuals actively seek out and select media based on their needs and motivations, and social media platforms are no exception. Understanding the uses and gratifications of social media among the Z Generation can provide valuable insights into their motivations and engagement patterns, leading to a better understanding of social media stickiness. According to the theory, individuals freely and intentionally choose the platform they will use to satisfy their needs (Hossain et al., 2019). Uses and gratifications were looked for in order to determine what the audience does with the media rather than what the media does to the audience (Falgoust et al., 2022; Moon et al., 2022). The theory investigates needs and how they are influenced by personal characteristics as well as the environment in which social interactions occur (Silveira et al., 2022).

Social media plays a significant role in the digital lives of the younger generations and has developed into much more than a tool for social connections (Ibáñez-Sánchez et al., 2022). Moon and An (2022) explained that Uses and Gratifications Theory motivates users to use the social platform and gratifies their informational and educational needs. Uses and Gratification Theory focuses on finding the reason behind every choice of audience related to a particular media. Social media usage facilitates the overall needs and requirements of the young generation today (Florenthal, 2019). Gen Z uses social media more than Gen Y for education, interaction, entertainment, and convenience (Silveira et al., 2022). There are four uses and gratifications motivations of social media, which include social interaction, information, entertainment, and convenience. People choose which media to consume based on their desire for goal-oriented pleasure to meet their psychological demands. In this approach, several media

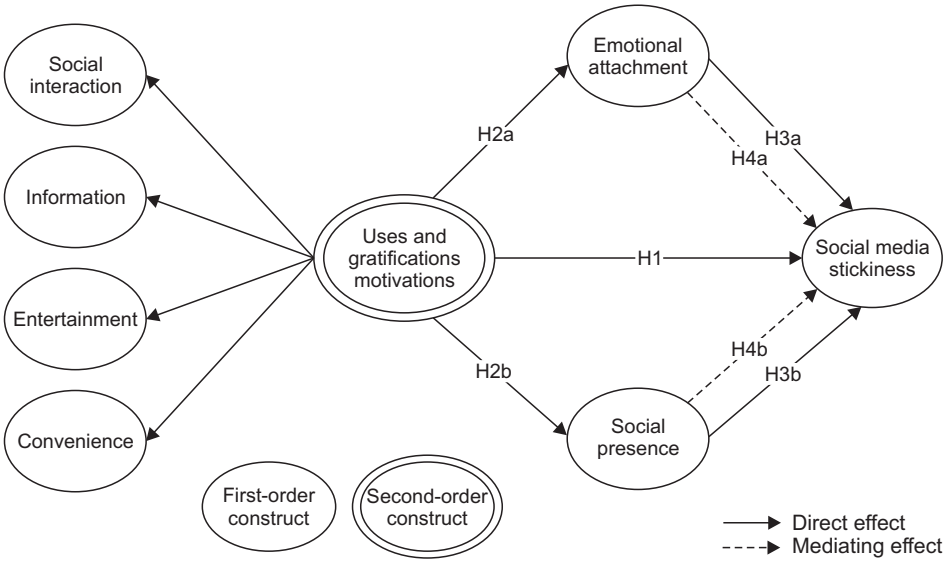


Fig. 1. Conceptual research model. H, hypothesis.

platforms fight for users' attention and to shape their subsequent behavior, and variations in user behavior are linked to the usage of a particular medium (Habes et al., 2022); so, social media use is predicted to have a favorable impact on social media stickiness in the Z Generation, in line with the Uses and Gratification Theory's justification. In light of the foregoing reasoning, we suggested the conceptual research paradigm depicted in Fig. 1.

3. HYPOTHESIS DEVELOPMENT

3.1. Uses and Gratifications Motivations and Social Media Stickiness

The younger generation of today has profited significantly from social media in many areas of their life, including social, personal, and other spheres. This is due to the fact that social media's function and position in young people's lives has significantly altered over the last 20 years (Khaola et al., 2022; Silveira et al., 2022). Compared to Gen Y, Gen Z utilizes social media more often (Ortiz et al., 2023). Social media is used both actively to create content and send messages as well as inactively to entertain, interact, and search for people, events, and information (Ibáñez-Sánchez et al., 2022). Moon et al. (2022) stated that people can keep up with what is going on in the world because social media gives them access to a wider range of news and information.

Marjerison et al. (2022) explained that users seek social interactions and connections through social media platforms to satisfy their need for companionship and social validation. Social media is changing and making it easier for people to interact with each other, which is important for building communities, bringing people together, and making connections between people with similar interests and connections (Wukich, 2022). Hansen et al. (2018) affirmed that social media sites have made it easier for people to meet with their friends in their area, across the country, and even around the world. It has also given people a place to meet each other. Habes et al. (2022) argued that the effects of social media are good for young people and change the way people connect and talk to each other. The more users fulfill their social interaction needs on social media, the more likely they are to stay engaged and loyal to the platform.

Moon et al. (2022) stated that the most important reason why people keep using social media is to have fun and be entertained. The level of entertainment determines how interesting and fun a social media site is for users. Habes et al. (2022) argued that the audio and video material on social media sites let people read, watch, and listen to the shows they want. Every day, more and more people use social media in this way. Cunningham and Craig (2017) stated that users engage with content that is entertaining, humorous, or emotionally captivating. Moon et al. (2022) reveal that users who find social media enjoyable and engaging as a means of escapism are more likely to continue using the platform and seek out new content regularly.

Social media and technology make it easier for people to stay in touch with family and friends all over the world through email, text, FaceTime, etc., and give them quick access to information and essential materials related to study. People know more about what is going on in other parts of the world because of it (Moon & An, 2022). Oeldorf-Hirsch and Srinivasan (2022) stated that social media platforms offer a vast amount of information on various topics, ranging from news and current events to personal interests and hobbies. It is also practical for individuals since it enables them to communicate by sharing their ideas and opinions and keeping up with current events. Silveira et al. (2022) explained that users who are motivated by the desire for information are likely to spend more time on social media, browsing content, following influencers, and participating in discussions. Qin (2020) suggests that users who perceive social media platforms as valuable sources of information are more likely to remain active and use them continuously.

Therefore, the more effectively social media platforms fulfill users' needs for social interaction, information, entertainment, and convenience, the higher the stickiness of the platform, leading to increased user engagement and prolonged usage. Consequently, the following hypothesis is put forwards.

> Hypothesis 1 (H1): Uses and gratification motivations have significant positive effects on social media stickiness.

3.2. Uses and Gratifications Motivations and Social Media Engagement

Social media are a group of web-based tools that allow people to make and share their own content. Cao et al. (2021) mentioned that as a social media contextual aspect, uses and gratifications motivations have a beneficial impact on an individual's participation, including their consumption, contribution, and creative behaviors. Individual participants' motivations in social media engagement are often goal-directed. Bucknell Bossen and Kottasz (2020) stated that social media platforms provide people

with a hands-on way to connect with a business and add value. Users who want to connect with other people are more likely to take part in chats, like and comment on posts, and start relationships with others on social media (Caron, 2016; Kujur & Singh, 2020). Suplico-Jeong et al. (2022) stated that social interaction is more likely to develop emotional attachments to social media platforms. Emotional attachment leads to increased engagement as users actively seek out and maintain relationships with others, participate in online communities, and experience a sense of emotional connection with the platform (Kujur & Singh, 2020).

Users who are looking for information are more likely to do things like read articles, follow news accounts, and take part in conversations about things that interest them (Wukich, 2022). Bucknell Bossen and Kottasz (2020) added that emotional attachment arises from the perception that the platform provides valuable and reliable information, leading users to engage deeply with the content, actively seek out information, and share their discoveries with others. Emotional attachment comes from the feeling of personal connection and joining that users get when they interact with material and groups that reflect their interests and identities (Moon et al., 2022). Falgoust et al. (2022) stated that users may develop a sense of emotional dependence on the platform for amusement and use it as a means of emotional relief and relaxation. Users who use social media platforms for these reasons are likely to form a strong emotional attachment with social media, which should lead to more involvement and continued use over time. Thus, the following hypothesis is proposed.

Hypothesis 2 (H2a): Uses and gratifications motivations have significant positive effects on emotional attachment.

Hossain (2019) argued that Uses and Gratifications Theory significantly influences social media engagement in terms of social presence, leading to increased user activity and a sense of connectedness on social media platforms. Marjerison et al. (2022) stated that users who are motivated by information seeking are more likely to engage actively on social media, aiming to establish a social presence based on their knowledge and expertise. They engage in discussions, share informative content, and seek opportunities to demonstrate their understanding of relevant topics to enhance their social presence. Silveira et al. (2022) concluded that users who are motivated by entertainment and escapism are more likely to engage actively on social media, aiming to establish a social presence that reflects their interests and personality. They actively consume and share entertaining content, participate in viral trends, and engage with others through playful interactions to enhance their social presence. Therefore, we assume that those motivational factors may encourage social media users to actively participate in activities that boost their social presence, build relationships, and create a feeling of community. Thus, the following hypothesis is proposed.

Hypothesis 2 (H2b): Uses and gratifications motivations have significant positive effects on social presence.

3.3. Social Media Engagement and Social Media Stickiness

Engaging with content on social media provides users with a sense of connection, validation, and social interaction. When users feel engaged and connected, they are more likely to continue using the platform to maintain these social connections (Cheung et al., 2022). The availability of new news distribution channels on today's social media platforms pushes Generation Z to utilize social media constantly, because individuals may now participate more in the production and transmission of news; hence reading and sharing it on social media has become a common activity (Dolan et al., 2016; Wukich, 2022). Emotional attachment and social presence are two important dimensions of social media engagement that can contribute to social media stickiness among Generation Z. Suplico-Jeong et al. (2022) argued that emotional attachment acts as a motivator for users to continue using the platform, as they seek positive experiences. Silveira et al. (2022) stated that higher levels of emotional attachment and social presence will lead to increased social media stickiness. Marjerison et al. (2022) stated that users who are active on social media are better able to decide what is important to them. Additionally, it enhances their academic achievement. Regular engagement with social media content can lead to habit formation. When users develop a habit of using a specific platform, it becomes a routine part of their daily lives, making it harder for them to switch to a different platform. The more users engage with the platform, the more likely they are to continue using it due to the habit they have formed. Cheung et al. (2022) suggests that engaging with content allows social media platforms to gather data about users' preferences and interests. With this information, platforms can personalize the content

users see, making it more relevant and appealing to them. When users consistently find content that matches their interests, they are more likely to stay engaged and stick with the platform.

All the above-mentioned benefits individuals can encompass by engaging with social media. If they are gratified by using social media, they will use social media continuously. Hossain et al. (2019) explained that social presence is not a major issue for users' social media stickiness. Moon and An (2022) concluded that when users feel a strong sense of social presence on a social media platform, they perceive the platform as a place where they can connect with friends, family, and communities. This feeling of being socially connected and engaged encourages users to remain active on the platform, resulting in increased social media stickiness. Therefore, we assume that individuals who are engaged in social media tend to use social media continuously. Thus, the following hypothesis is proposed.

Hypothesis 3 (H3a): Social media engagement (emotional attachment) has significant positive effects on social media stickiness.

Hypothesis 3 (H3b): Social media engagement (social presence) has significant positive effects on social media stickiness.

3.4. Uses and Gratifications Motivations, Social Media Engagement, and Social Media Stickiness

Engagement serves as a bridge between the reasons users are motivated to use social media and the outcomes of their continued use (Cheung et al., 2021). Through active engagement, users experience and derive the gratifications they seek, further influencing their attachment and stickiness to the platform. By actively participating and interacting on social media, users have more opportunities to connect with others, express themselves, seek information, find entertainment, and build their online identities (Sangwan et al., 2022). As users consistently engage with social media platforms and experience gratifications, their level of attachment, social presence, and stickiness to the platform increases.

Engagement behaviors are a result of motivational influences, consistent with the theoretical underpinning of Uses and Gratifications Theory (Bucknell Bossen & Kottasz, 2020; Dolan et al., 2016). Gratification on social media tends to stimulate continuous use intention (Marjerison et al., 2022). Silveira et al. (2022) mentioned that users, especially Generation Z, use social media for information gathering, entertainment, social interaction, and convenience. If they are gratified by using social media, they will use social media frequently, but if they engage with social media, they will use social media on a continuous basis. Emotional attachment and social presence lead to gratification, which stands to affect social media stickiness in users of specific media (Wukich, 2022). Marjerison et al. (2022) argued that individuals who are gratified by using social media and are engaged with social media have stickiness with social media. Therefore, we assume that social media engagement factors such as emotional attachment and social presence have a significant positive influence on uses and gratifications motivations and social media stickiness in users. Thus, the following hypotheses are proposed.

Hypothesis 4 (H4a): Social media engagement (emotional attachment) has a mediating effect on the relationship between uses and gratifications motivations and social media stickiness.

Hypothesis 4 (H4b): Social media engagement (social presence) has a mediating effect on the relationship between uses and gratifications motivations and social media stickiness.

4. RESEARCH METHODOLOGY

4.1. Sample Characteristics

We created a survey questionnaire by reviewing the literature and using a three-step approach. First, we identified the questionnaire items through a literature review. Then, we improved the comprehensibility and clarity of the questions, limited the number of questions, and eliminated redundant ones. Next, we conducted a pilot study on 20 randomly selected samples to determine the suitability of the measurement questions. We used Google Forms to conduct the survey, which was disseminated via social media to Z Generation social media users who are residents of Bangladesh. We deliberately collected data from Z Generation (e.g., people who were born in the generation between the middle of the 1990s and the middle of the 2010s). We utilized filtering questions to determine whether respondents were born between 1990 and 2000, and we advised them to continue the survey only if those years corresponded to their birth year. If otherwise, participants were advised not to continue answering the survey questions. Additionally, when screening the

data, we looked at the age of the respondents. Only a few of them had ages that did not coincide with the reported birth years; as a result, those responses were excluded from the final study. Our data samples thus represent the Generation Z population, which is the one most likely to use technology advancements.

The survey questions used a seven-point scale. A pilot test with 20 individuals was conducted to confirm that the questionnaire was thorough enough. We collected 280 valid samples and eliminated duplicates, unexpected responses, and errors to obtain 258 good samples for analysis. To improve validity and reliability, we used widely used measurement questions from the literature. Finally, we made minor modifications and changes to improve the readability and clarity of the questions before finalizing the questionnaire.

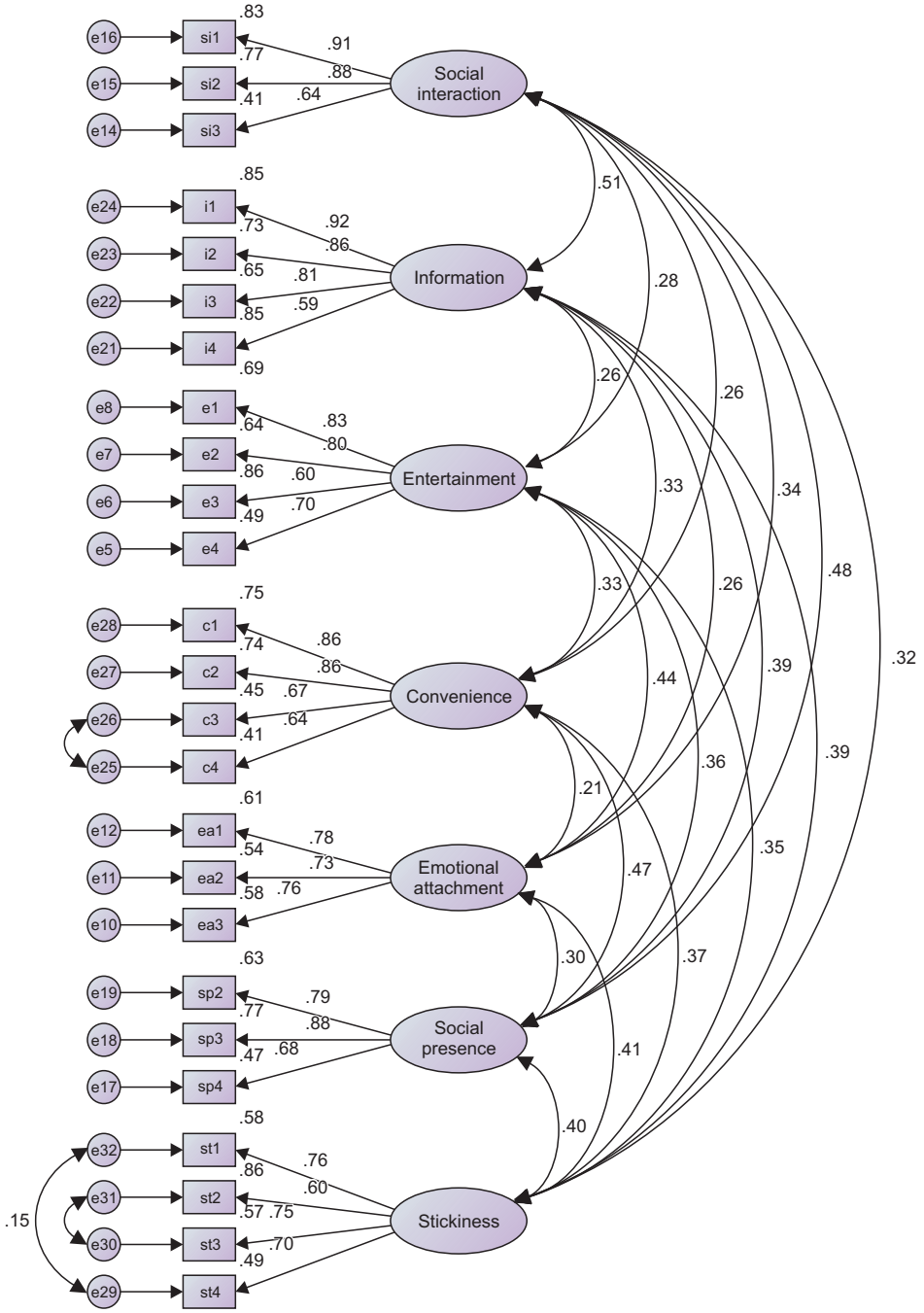


Fig. 2. Measurement model.

4.2. Tools and Analysis

In order to assess reliability and provide theoretical explanations for correlations between constructs inside the structural model, we employed structural equation modeling (SEM) as a method of data analysis. The IBM SPSS Amos 24 (IBM Co., Armonk, NY, USA) program is employed because it provides accurate measurement and structural model estimation in real time. Using the two-stage process, we first examined the measurement model and then assessed the structural model. In contrast to the structural model, which explores the associations between constructs and things, the measurement model zeroes down on the underlying mechanisms through which items and constructs are related to one another. Within the framework of the measurement model, the study constructs' reliability and convergent validity were assessed.

Additionally, SEM is the most appropriate method for our study because our research model suggested complicated interactions between the independent and dependent variables. Our model first considered multidimensional variables to validate the uses and gratifications motivations. The current study empirically validates these multidimensional factors (e.g., social interactions, information, entertainment, and convenience) using a second-order construct development, in which SEM is incredibly useful. Thereafter, we tested measurement reliability, validity, and structural relationships among the considered variables showing in Fig. 2 and Fig. 3. Both models show model fitness, which is essential to reach decisions on fit testing. Finally, the current study proposed a few mediation effects in the model, which is credibly analyzed in SEM. Consequently, the use of SEM is ideal in the context of this research.

5. EMPIRICAL RESULTS

5.1. Demographic Information

The sample consisted of 258 Z Generation social media users. Most participants were students, followed by government employed, private employed, businesspeople, and a small proportion of other individuals. In terms of sex, many participants were male (215). Participants' ages showed that most participants were between 23 and 25 (Table 1). Most participants had been using social media daily for 30-50 minutes, with some having less than 30 minutes, some having 50-80 minutes, and others having

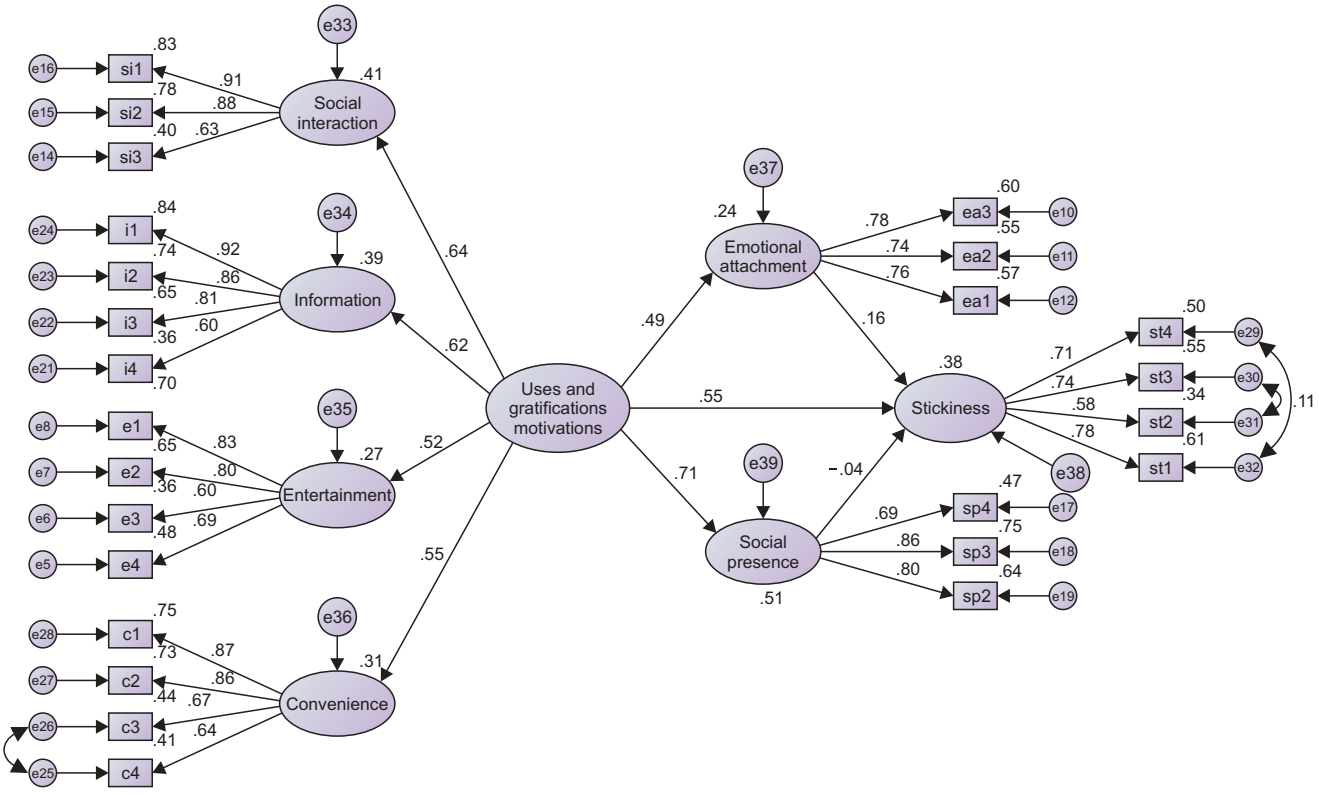


Fig. 3. Structural model.

Table 1. Demographic characteristics (n=258)

Factor	Frequency
Sex	
Male	215
Female	43
Participants' age (yr)	
18-22	45
23-25	105
26-28	44
29-31	64
Participants' profession	
Student	123
Government employed	49
Private employed	38
Business	36
Others	12
Social media usage per day (min)	
<30	32
30-50	96
50-80	55
>80	75

Source: Survey data.

more than 80 minutes daily. The sample represented Z Generation social media users with a mix of ages and profession, and varying levels of daily social media uses. Table 1 presents a detailed view of respondent demographics including participants' sex, age, profession, and social media uses per day.

5.2. Exploratory Factor Analysis and Descriptive Analysis

Table 2 provides descriptive statistics for the independent variable uses and gratifications motivations and the constructs social interaction, information, entertainment, and convenience that influence social media stickiness and social media engagement in social media use intention. The mean scores for all constructs were above the midpoint of the scale, indicating that users consider these factors to be gratified in their social media uses. The skewness values for all constructs were negative, suggesting that most responses were towards the higher end of the scale, and the kurtosis values were mostly positive, indicating that the data had heavy tails and were more peaked than in a normal distribution. Overall, these descriptive statistics provide an initial understanding of the motivations that influence social media stickiness in social media use.

5.3. Measurement Model Analysis

To assess the quality of the measurement instrument, we employed indicators of construct reliability, validity, and model fit (Fig. 2). Examining the t-values, *p*-values, squared multiple correlations, and factor loadings for each question in Table 2 ensures the study is valid and reliable.

This research produced a measurement model for the evaluations of convergent and discriminant validity that were performed to verify the validity and reliability of the measurement model. Finally, the results of the measurement model are reviewed in order of fitness, validity, and reliability. It is shown in Table 3 that all measures are credible since the standardized factor loadings for all variables are adequate and meet the threshold for statistical significance (Fornell & Larcker, 1981). All Cronbach's alphas are above the 0.7 level, which may be considered statistically significant (Hair et al., 2010). Composite reliability values in the range of 0.90 to 0.96 are higher than the bare minimum of 0.70 (Hair et al., 2010). Each variable has an average variance extracted (AVE) that is more than 0.50, varying from 0.51 to 0.66. The least square root of the AVE values is less than the correlation coefficients of all possible combinations of sub-dimensional components (Table 4). As a result, the conditions for convergent validity and discriminant validity are met. X^2/df=1.938, goodness-of-fit indices (GFI)=0.867, incremental fit indices (IFI)=0.929, average goodness-of-fit Indices (AGFI)=0.828, comparative fit indices (CFI)=0.923, Tucker-Lewis index (TLI)=0.913, and root mean square error of approximation (RMSEA)=0.060 are all well within their tolerance limits, indicating that the measurement model is generally well-fit (Hu & Bentler, 1999). Hence, the data's model fits are sufficient (Table 5) (Browne & Cudeck, 1993; Doll et al., 1994; Hair et al., 2010).

5.4. Structural Model Analysis

The results of the model fit scores show that our structure model fits pretty well (Table 6). Fig. 3 indicates the structural paths among constructs in our conceptual model.

5.5. Hypothesis Results

Table 6 displays the findings of several hypotheses concerning the connection between distinct variables. This

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Table 2. Rotated component matrix

Item	Factor						
	1	2	3	4	5	6	7
i1	0.840						
i2	0.825						
i3	0.852						
i4	0.703						
c1		0.796					
c2		0.818					
c3		0.786					
c4		0.793					
e1			0.797				
e2			0.844				
e3			0.708				
e4			0.723				
st1				0.796			
st2				0.741			
st3				0.812			
st4				0.709			
si1					0.877		
si2					0.873		
si3					0.651		
ea1						0.783	
ea2						0.821	
ea3						0.807	
sp2							0.825
sp3							0.844
sp4							0.659

Extraction method: Principal component analysis.
Rotation method: Varimax with Kaiser normalization.
Rotation converged in 7 iterations.

table compares four motivations about the causes of social media uses and gratifications and the decision of stickiness with social media. Emotional attachment and social presence as social media engagement factors were considered by the theories. In particular, since we presented uses and gratifications motivations as multidimensional, accordingly our second order model demonstrates that all proposed dimensions (e.g., social interaction [coefficient (β)=0.64, coefficient of determination (r^2)=0.40], information [β=0.63, r^2=0.38], entertainment [β=0.52, r^2=0.28], and convenience [β=0.55, r^2=0.30]) are highly loaded to uses and gratifications motivations. All of the offered hypotheses were found to be significantly accepted by our findings, with the exception of the association between social presence and social media stickiness. Thereby H1 (β=0.55), H2a (β=0.49), H2b (β=0.71), and H3a (β=0.19) are accepted, and only H3b (β=-0.04) is rejected. Table 7 provides estimates and p-value for each hypothesis.

The r^2 assesses predictability in the study's constructs. The adjusted r^2 is updated to account for sample size and new independent variables. The r^2 represents the proportion of variance in the dependent variable explained by

Table 3. Measurement model validity statistics

Item	Estimate	S.E.	C.R.	*p*	Alpha value
si3 ← Social interaction	0.637				0.84
si2 ← Social interaction	0.878	0.119	11.175	***	
si1 ← Social interaction	0.911	0.121	11.250	***	
i4 ← Information	0.591				0.87
i3 ← Information	0.806	0.125	9.846	***	
i2 ← Information	0.857	0.127	10.207	***	
i1 ← Information	0.924	0.135	10.554	***	
e4 ← Entertainment	0.703				0.81
e3 ← Entertainment	0.603	0.094	8.682	***	
e2 ← Entertainment	0.801	0.089	11.109	***	
e1 ← Entertainment	0.829	0.097	11.329	***	
c4 ← Convenience	0.639				0.85
c3 ← Convenience	0.668	0.087	11.076	***	
c2 ← Convenience	0.859	0.119	10.670	***	
c1 ← Convenience	0.865	0.117	10.690	***	
ea3 ← Emotional attachment	0.759				0.80
ea2 ← Emotional attachment	0.735	0.094	10.322	***	
ea1 ← Emotional attachment	0.781	0.091	10.641	***	
sp4 ← Social presence	0.683				0.82
sp3 ← Social presence	0.875	0.126	11.280	***	
sp2 ← Social presence	0.794	0.103	10.884	***	
st4 ← Stickiness	0.700				0.82
st3 ← Stickiness	0.752	0.156	7.284	***	
st2 ← Stickiness	0.598	0.146	6.391	***	
st1 ← Stickiness	0.761	0.103	10.517	***	

Source: SEM output.
S.E., standard error; C.R., critical ratio.
***p<0.001.

the independent variable. Table 6 also shows that social presence explains 51% of the variance, emotional attachment explains 25%, and stickiness explains 38% of the variance in Generation Z's stickiness with social media.

5.6. Mediation Analysis

Table 7 shows results of a mediation model exploring the link between uses and gratifications motivations and social media stickiness via emotional attachment and social presence. Estimates and bootstrapping results are presented, including the indirect effect of uses and gratifications motivations on social media stickiness through emotional attachment and social presence. The estimated indirect effect of emotional attachment is β=0.011, with a 95% confidence interval of 0.006 to 0.085 and a p-value <0.001, indicating significant mediation. The estimated indirect effect of social presence is β=0.081 with a 95% confidence interval of -0.21 to 0.410, indicating insignificant mediation, representing accepting H4a and rejecting H4b. Table 7 provides criteria for interpreting significance.

6. DISCUSSION

The current study investigates the complex link be-

Table 4. Validity statistics

Variable	CR	AVE	1	2	3	4	5	6	7
1. Entertainment	0.83	0.56	0.75[a)]						
2. Emotional attachment	0.80	0.58	0.440	0.76[a)]					
3. Social interaction	0.85	0.66	0.283	0.338	0.81[a)]				
4. Social presence	0.82	0.62	0.358	0.303	0.476	0.78[a)]			
5. Information	0.88	0.65	0.258	0.262	0.509	0.387	0.80[a)]		
6. Convenience	0.85	0.58	0.327	0.206	0.256	0.468	0.333	0.76[a)]	
7. Stickiness	0.80	0.51	0.347	0.414	0.321	0.400	0.395	0.372	0.70[a)]

CR, composite reliability; AVE, average variance extracted.
[a)]Values are the square root of AVEs.

Table 5. Model fit results

Index	Recommended value	Obtained value measurement model	Obtained value structural model	References
CMIN/df	<3	1.938	1.975	Hair et al. (2010)
CFI	≥0.90	0.923	0.921	Hair et al. (2010)
GFI	≥0.80	0.867	0.857	Doll et al. (1994)
AGFI	≥0.80	0.828	0.823	Doll et al. (1994)
IFI	≥0.90	0.929	0.922	Hair et al. (2010)
TLI	≥0.90	0.913	0.910	Hair et al. (2010)
RMSEA	≤0.08	0.060	0.062	Browne & Cudeck (1993)

Source: Data analysis results.
CMIN/df, chi-square to degrees of freedom; CFI, comparative fit indices; GFI, goodness-of-fit indices; AGFI, average goodness-of-fit indices; IFI, incremental fit indices; TLI, Tucker-Lewis index; RMSEA, root mean square error of approximation.

Table 6. Hypothesis results

Hypothetical path	Estimate	*p*	Decision
Social interaction (r^2=0.40) → Uses and gratifications motivations	0.639	<0.001	Highly loaded
Information (r^2=0.38) → Uses and gratifications motivations	0.623	<0.001	Highly loaded
Entertainment (r^2=0.28) → Uses and gratifications motivations	0.521	<0.001	Highly loaded
Convenience (r^2=0.30) → Uses and gratifications motivations	0.554	<0.001	Highly loaded
Uses and gratifications motivations → Stickiness	0.549	<0.001	H1: accept
Uses and gratifications motivations → Emotional attachment	0.494	<0.001	H2a: accept
Uses and gratifications motivations → Social presence	0.712	<0.001	H2b: accept
Emotional attachment → Stickiness	0.197	<0.05	H3a: accept
Social presence → Stickiness	-0.040	Not significant	H3b: reject
Squared multiple correlation			
Social presence (r^2=0.51)			
Emotional attachment (r^2=0.25)			
Stickiness (r^2=0.38)			

r^2, coefficient of determination; H, hypothesis.

Table 7. Mediation results

Mediating path	Indirect effect	Error	Bootstrapping results[a)]			
			Lower bound	Upper bound	*p*-value	Decision
Uses and gratifications motivations → Emotional attachment → Stickiness	0.011	0.017	0.006	0.085	<0.001	H4a: accept
Uses and gratifications motivations → Social presence → Stickiness	0.081	0.093	-0.21	0.410	Not significant	H4b: reject

Source: Data analysis results.
H, hypothesis.
[a)]Bias-corrected model with 95% confidence interval.

tween uses and gratifications motivations, social media engagement, and social media stickiness. The goal of this study is to find out how uses and gratifications drive people to use social media, which make people more likely to keep using social media. We also want to find out what part social media engagement plays between uses and gratifications motivations and how long people stay on social media. The results show that four types of motivations, including social interaction, information, entertainment, and convenience, have a significant impact on social media stickiness within Z Generation. Social interaction exerts the largest positive impact on social media stickiness, followed by information, convenience, and entertainment. These results are in line with what other studies have found (Habes et al., 2022; Hossain et al., 2019; Moon & An, 2022). These results reveal that social media users use social media for social interaction. They feel gratified when finding useful and valuable information through social media, which encourages continuous use of social media. Also, people who use social media think it is nice, interesting, and fun to do so.

Eventually, this study indicates that uses and gratifications motivations have a direct effect on social media stickiness. It is now possible to say that the main gratifications obtained from using social media are social interaction, information, entertainment, and convenience. This conclusion is partially supported by previous findings (Moon et al., 2022; Silveira et al., 2022). This result is also consistent with Hossain et al. (2019)'s findings, indicating that the most important reasons people use social media are to have fun, to get knowledge, to connect with other people, and to conform to their own ideas of what is right and wrong. In Table 7 the results of the present investigation demonstrate that uses and gratifications motivations have a substantial favorable effect on social media stickiness. Consequently, H1 was confirmed.

According to what we thought would happen and what other studies have shown (Busalim et al., 2021; Cheung et al., 2022), we find a high association between uses and gratifications motivations and social media engagement in Z Generation users of social media. This study finds that uses and gratifications motivations have a positive impact on emotional attachment and this emotional attachment had the strongest impact on social media stickiness in social media users, which shows that the compliance process appeared to be important in the uses and gratifications motivations context. The findings support H2a and H3a. Hence, it can be inferred that there is a favorable correlation between uses and gratifications motivations and emotional attachment and social media stickiness within Generation Z. Interestingly, we find a too-high association between uses and gratifications motivations and social presence in Z Generation users of social media. The findings support H2b.

Contrary to our expectations, social presence was not found to have significant impacts on social media stickiness in Z Generation social media users. The findings reject H3b. A possible reason could be that social media stickiness encompasses various dimensions while social presence may not be the sole determinant of social media stickiness. In other words, Generation Z is known for its ability to navigate between different social platforms and communicate through a variety of mediums beyond traditional social media. They may engage in real-time messaging apps, video-sharing platforms, or niche online communities. This generation values instant and authentic communication, seeking platforms that provide immediate gratification and a sense of belonging. Thus, social presence alone may not be the primary driver of stickiness, as Generation Z seeks a broader range of social interactions and experiences. The users may depend entirely on enjoyment, information seeking, convenience, or real-world social interactions about these dimensions of gratification. Additionally, the Uses and Gratifications Theory

suggests that individuals choose media platforms based on their needs and motivations. For Generation Z, social media serves multiple purposes beyond social interaction, such as self-expression, information sharing, entertainment, and identity construction. While social presence can contribute to certain gratifications, it may not be the central factor driving stickiness for this generation. Therefore, social presence is not among the major issue shown to affect social media stickiness in this study.

Social media engagement acts as a mediating variable that connects users' motivations and gratifications with their level of social media stickiness. The positive experiences derived from engagement reinforce users' connections to the platform, contributing to their continued usage, loyalty, and resistance to switching to alternative platforms. This also partially corroborates the findings of Habes et al. (2022), who concluded that social media engagement mediates the relationship between uses and gratifications motivations and social media stickiness. But Table 7 exhibits that not all dimensions of social media engagement influence the relationship between uses and gratifications motivations and social media engagement. Table 7 reveals that H4a is accepted (β=0.011, p<0.001), hence there is a mediation effect, revealing that social media engagement has stimulating power to strengthen the relationship between uses and gratifications motivations and stickiness. In other words, when social media users receive uses and gratifications motivations, and have become engaged with the media and other users, they intend to stay connected/experience stickiness for a longer period of time.

However, unexpectedly, H4b appears non-significant since it shows a zero value existing between the lower bound and upper bound in the bias-corrected model, with a 95% confidence interval. Since the lower bound shows a negative sign and the higher bound a positive one, there is zero between the two, indicating that the indirect effect of social presence is insignificant. These results reveal that, in the context of this study, users of social media may not be overly concerned with their social presence. This may have occurred as a result of the study sample we evaluated being in a broader social condition; the majority of the respondents are predominantly from diverse educational institutions, which already allowed them the opportunity to represent themselves. Another reason might be that, in the context of a collectivist society, participants are more likely to interact in person with their neighbors, friends, and other people in public places. As a result, it can be said that while the uses and gratifications motivations have made social media desirable to users, they are not yet sufficient to strengthen the relationship between uses and gratifications motivations and social media stickiness.

7. CONCLUSION

The Z Generation engages with social media platforms primarily to satisfy their psychological and social needs. They seek gratification in the form of entertainment, social interaction, information acquisition, and convenience. Social media platforms play a significant role in facilitating social interaction and connection for the Z Generation. The Z Generation utilizes social media as a source of entertainment and escapism. They consume various forms of content, such as videos, memes, and stories, to alleviate boredom and stress. They rely on platforms to stay updated on current events, trends, and topics of interest. However, there is a need for critical evaluation of information due to the prevalence of misinformation and fake news. The Z Generation experiences fear of missing out when disconnected from social media. They fear missing out on social events, trends, and important updates shared within their networks. This fear drives them to constantly engage with social media platforms to stay connected. The addictive nature of these platforms, combined with the fear of missing out, leads to a continuous cycle of checking and responding to notifications. Overall, the present study highlights the significant role of social media in the lives of Z Generation. They actively engage with these platforms to fulfill various needs, including social interaction, entertainment, convenience, and information seeking. The addictive nature of social media contributes to its stickiness among this generation. Thereby, we perceive that our proposed "RQ1: What are the main gratifications obtained from using social media, and how do they encourage Z Generation users to stick with that social media?" and "RQ2: Whether and to what extent does media engagement mediate the relationship between gratifications and stickiness?" have been satisfactorily taken into consideration. In conclusion, this study on social media stickiness in the Z Generation, based on the Uses and Gratifications Theory, holds theoretical and managerial implications across various domains.

7.1. Implications for Theory

The study on social media stickiness in the Z Generation, based on the Uses and Gratifications Theory, carries several theoretical and managerial implications into how users seek specific content or interactions on social media

to satisfy their individual needs and desires. First, understanding the factors that contribute to engagement and stickiness with social media platforms among this generation can offer various strategies and decisions to researchers and practitioners. Second, by stressing the relevance of user motives in shaping the stickiness or sustained involvement of individuals with social media platforms, these observations can enhance ideas linked to user-centric engagement. Awareness of the motivations, gratifications, and potential consequences of social media engagement can guide the development of responsible social media practices, promoting digital wellbeing, privacy, and ethical use. Third, the theoretical implications may imply that platforms might improve the distribution of information and interface designs, hence boosting stickiness, by identifying and accommodating the varied gratifications needed by users. This could aid in the creation of theoretical frameworks for the improvement of user interfaces and customized content recommendations. Four, the implications of this study extend to the realm of education. By promoting critical thinking, media literacy, and online safety, educational initiatives can empower young individuals to make informed decisions and leverage social media for positive purposes. Fifth, researchers may speculate about the long-term impact of these motivations on user loyalty if specific satisfaction motivations are proven to strongly influence stickiness. In order to do this, it may be necessary to investigate how particular pleasures, such as social contact, information searching, or entertainment, affect long-term involvement and the emergence of more solid user-platform bonds. Taking note of all of these factors, the current study sees a contribution of fresh knowledge to the body of literature.

7.2. Implications for Practice

The following are some implications for practitioners and managers. First, the current study can provide insights into the types of content that resonate with the Z Generation on social media. This understanding can help content creators and marketers tailor their strategies to meet the specific needs and gratifications of Generation Z. For instance, this may entail creating customized content that meets various demands for fulfillment, such as posts that provide education for people interested in learning, entertainment for those seeking leisure, or interactive elements for those seeking social connections. Second, this study can guide social media platform designers and developers in creating user satisfactions that align with the motivations and gratifications sought by the Z Generation. It can inform interface design, feature development, and overall platform architecture to enhance user engagement, satisfaction, and stickiness. For instance, platforms might give priority to features that enable meaningful connections, conversations, or group activities if the research emphasizes the importance of social interaction as an incentive for stickiness. Third, the findings of this study can be used to optimize advertising and promotional strategies on social media targeted at the Z Generation. For instance, if a platform's users are mostly driven by the desire for social connections, advertisers may choose to create ads that emphasize community development or feature user reviews that highlight the platform's capacity for fostering connections. Understanding their motivations and gratifications can help advertisers deliver more personalized and relevant messages, increasing the effectiveness of their campaigns. Fourth, educational institutions, organizations, and policymakers can benefit from this study's findings when formulating social media policies and guidelines for the Z Generation. Educators and institutions can leverage the findings to develop digital literacy programs and curricula that equip the Z Generation with the necessary skills to navigate social media effectively and responsibly.

7.3. Limitations

Even though this work makes important advances, it has a few limitations. First, the Z Generation group is not taken from all over the world, so it is risky to say that the results are true for all countries. Therefore, it is advised to exercise caution when extrapolating the findings to other contexts. In these regards, future studies are highly appreciated to conduct research in a cross-national context. Second, most of the people in the group were young because the study was about Generation Z. This could make the study even less useful for all ages, thus future researchers are suggested to look at all respective age groups. Third, our study was constrained with uses and gratifications motivations and their influence on social media stickiness along with mediators; some other important issues may be left, and thus in order to get more reliable results, future studies should use a longitudinal study method and look at other important factors in a more continuous way.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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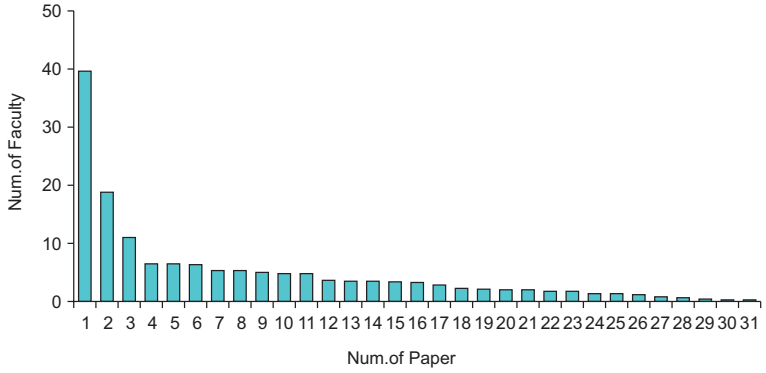


Fig. 1. Distribution of authors over publication count.

Table

Table 1. The title of table goes here

Study	Time period study	Data
Smith Wesson (1996)	1970 - 1995	684 papers in 4 SSCI journals
Reeves [a (2002)	1997 - 2001	597 papers in 3 SSCI journals
Jones Wilson [b (2011)	2000 - 2009	2,166 papers in 4 SSCI journals

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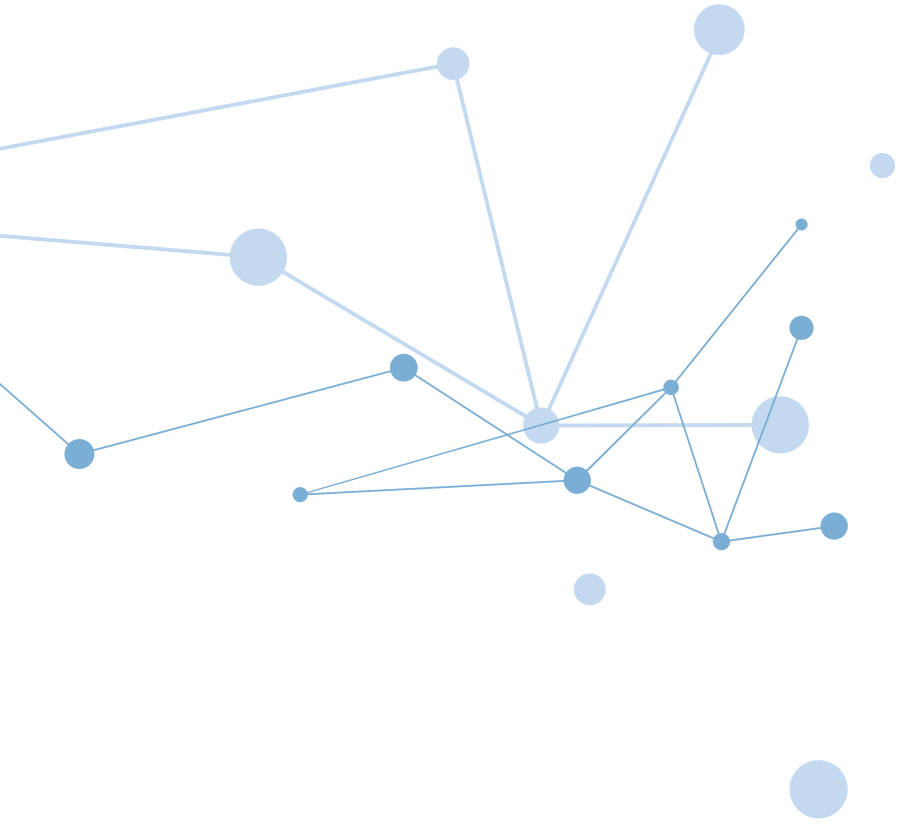
- Author, A., & Author, B. (Year). Chapter title. In A. Editor, B. Editor, & C. Editor (Eds.), *Book title* (pp. xx-xx). Publisher Name.
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