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TRANSPORTATION: THE AGATHOKAKOLOGICAL VEHICLE OF PANDEMIC TRANSMISSION AND MANAGEMENT

Summary. Discourses on pandemics often prioritize germane pharmaceutical issues while largely ignoring the social dimensions to them, especially the paradoxical role of transportation in pandemic transmission and management. Granted, from an epidemiological perspective, transportation is technically a vector of pandemics; however, by sustaining continuous critical supply chains and facilitating the conveyance of interventions during pandemics, transportation also plays a crucial role in pandemic control and management. Indeed, studies have shown that the risk of disease transmission can be significantly reduced by the observation of non-pharmaceutical transport protocols. Against this background, this paper highlights the dual roles of transportation in aiding and curbing pandemics, with a strong emphasis on the latter. Moreover, towards consolidating on the strengths of the transport sector in the control and management of public health issues, this paper underscores the sacrosanctity of responsible transport. Challenges were identified, and practicable recommendations were proffered towards containing them.

Keywords: COVID-19, pandemic transmission, pandemic control and management, pandemic-responsiveness, responsible transport, active transport

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1. INTRODUCTION: REDEFINING THE TRANSPORTATION-PANDEMIC INTERFACE

It is acceptable to both common knowledge and scientific analyses that transportation aids the transmission of infectious diseases and pandemics [5, 26, 42, 47, 51, 56, 63, 64]. However, the role and potential of transportation in the control and management of pandemics are generally rarely duly acknowledged. Indeed, discourses on pandemics usually prioritize such germane issues as containment, treatment protocols, and medication (including vaccination) while largely ignoring the social dimensions to them, especially the paradoxical role of transportation in both the transmission and management of global public health challenges.

Arguably, the relationship between the duo of transportation and pandemics could be understood in two major successive dimensions [41]. First, transportation contributes in a major way to the spread of pandemics. Second, it ensures the continuity of critical supply chains during pandemics, especially when lockdowns become expedient, as well as provides the means and modes for spatial interactions through which medical and pharmaceutical interventions are produced and supplied. The latter role necessarily relates to pandemic control and management, especially with the acknowledgement of the complementary role of non-pharmaceutical protocols.

An all-inclusive analysis and contextualization of the interconnectedness between transportation and pandemics is imperative for a thorough understanding of the indispensability of transportation in overall pandemic control and management; however, a dearth of research insufficiently addresses these holistically in the literature. Consequently, this paper attempts to update the literature and advance the frontiers of existing narratives on the transportation-pandemic interface, as well as chart the course for a possible paradigm shift.

2. TRANSPORTATION AS A DRIVER OF PANDEMIC TRANSMISSION

Infectious diseases have affected humanity for centuries [2, 28, 32, 36, 44, 54], and the contribution of transportation to their spread has long been established. In the train of ubiquitous and efficient transportation is a quick and widespread transmission of infectious diseases [7, 8, 41]. Even years before the onset of COVID-19, the latest of the pandemics, it had been postulated that public transport systems were involved in intensifying and speeding up the spread of influenzas and associated viruses across the globe. This is a consequence of the thronging of hordes of passengers within enclosed areas, creating an environment conducive to the easy transmission of infections among the passengers through the inhalation of droplets and aerosols of virus suspended in the air [20].

In the last three centuries, ten major influenzal pandemics have struck all over or at many different parts of the world. The Spanish Flu of 1918 is still regarded as the worst [10, 41]; it saw almost a third of the entire world's population becoming ill, and up to a hundred million people losing their lives. Further, the 21st century has witnessed several severe communicable disease outbreaks. Various infectious diseases ranging from the currently ravaging multivariant COVID-19 pandemic, with a devastating impact on both the lives and livelihoods of people worldwide, to the severe acute respiratory syndrome coronavirus outbreak of 2003, the swine flu pandemic of 2009, the respiratory syndrome coronavirus outbreak of 2012 in the Middle East, the West African Ebola virus disease epidemic between 2013 and 2016, as well as the Zika virus disease epidemic of 2015, have afflicted billions of people globally. These diseases

have brought about considerable morbidity and substantial mortality figures as they spread unfettered from border to border, infecting people across nations and regions [2].

One important factor aiding the quick and extensive spread of diseases is modern transportation, which has been offering global coverage for well over a century now. Often, infected crews and passengers spread these diseases as they move from one part of the world to another in trains and ships; most times, severe cases of the epidemics were recorded among railway personnel and in shipyards. In more recent times, such outbreaks as the 2002-2003 severe acute respiratory syndrome (SARS), the 2005 Avian Flu, and the 2009 Swine Flu, as well as the rapidly evolving COVID-19, quickly spread largely owing to the readily available, efficient and convenient air travel, which makes any part of the globe easily accessible [41]. Therefore, epidemiologically viewed, it is arguable that transportation is technically a veritable vector of pandemics [9, 15, 41, 58, 59].

3. THE ROLE OF TRANSPORTATION IN PANDEMIC CONTROL AND MANAGEMENT

In discourses on pandemics, transportation is evidently a necessary evil. It contributes to the globalisation and the control and management of pandemics. In other words, its aiding pandemic transmission notwithstanding, transportation also helps in the control and management of pandemics. This is done in two significant ways. First, without transportation, the logistics needed for the continued supply chains of critical stocks during pandemics would be non-existent. Second, transportation aids spatial interactions, even during pandemic-induced lockdowns, thereby facilitating the conveyance of medical and pharmaceutical interventions as well as medical personnel and essential workers during pandemics.

Usually, during outbreaks of pandemics, lockdowns become necessary. Evidently, failure on the part of the government to curtail the spread of pandemics at such critical times could be costly. For instance, according to Colonna and Intini [12], based on an empirical experience from Italy, damage from loss of human capital and healthcare costs could have been fully compensated if lockdowns had been imposed ten days earlier than it was. At a time, the COVID-19 pandemic aggressively ravaged the national and global economies, public health was alarmingly compromised, and people's livelihoods were severely threatened with well over 3,600,000 infections and 250,000 mortalities worldwide. This informed the drastic measures taken by governments in many countries towards thwarting the unrelenting spread of the pandemic [6, 19, 27]. Thus, approximately half of all the people in the world had their mobility restricted as international borders were shut leading to a sharp decline in economic activities as many countries suspended many businesses deemed non-essential [4, 19, 52].

Whenever lockdowns are introduced during pandemics, freight distribution usually attracts a lot of attention. The rationale for this consists in the reality that once the continuous supply of some vital resources and consumables is discontinued, the sustenance of the economy becomes practically impossible [40]. Furthermore, transportation provides the means and modes of mobility for medical workers and interventions during pandemics. According to WHO [60], the success of any vaccination or immunization programme hinges on an efficient supply chain, as well as functional logistics systems, which are needed for the efficient storage and handling of vaccines and their stock management, the cold chain of which painstaking and constant temperature control is required. This is in addition to the maintenance of high-level logistics management information systems that guarantee the continuous availability and supply of top-quality vaccines from the point of production to the point of use via an efficient

supply chain. It is ensured that no opportunity to get anyone vaccinated is missed just because the vaccines to be used are not available. Thus, a system must be put in place to ensure that the established six conventional rights of an ideal supply-chain management are achieved. These translate to having the right product in the right quantity in the right condition in the right place at the right time and at the right cost.

In 2020, certain goals were set for mass vaccination. According to the World Trade Organization (WTO) [62], it was expected that by the end of 2020, the yearly production capacity of COVID-19 vaccines would have reached 610 million doses and that the target of one billion doses would be met by the following year. It was also projected that the monthly production capacity of the COVID-19 vaccine would reach 5 million doses by the first month of 2021. Subsequently, for example, the United States government planned to produce and deliver up to 300 million doses of the COVID-19 vaccine by the beginning of 2021. This was part of a long-range plan targeted at accelerating the production and global distribution of COVID-19 medication and remedies in vaccine, therapeutic and diagnostic forms. As many as two billion COVID-19 vaccine doses were planned for worldwide distribution, with a target set for the end of 2021 and an allocation proposed for approximately a fifth of the population of each country to have prioritized target groups covered.

Without transport systems to provide the time and place utilities, it would be impossible to effectively deliver the required doses of vaccines around the world. The handling and delivery of vaccines must observe global regulatory standards, which stipulate controlled temperatures and an uninterrupted supply chain to ensure that the quality of the product is not at any point compromised [23]. Consequently, since the onset of the COVID-19 public health emergency, aviation stakeholders such as government agencies, air carriers and others have worked proactively together towards enabling safe and efficient transportation of critical medical supplies and personnel by air [16]. Thus, transportation constitutes an integral part of the solution to the problem to which it has largely contributed. This underscores the imperativeness of prioritizing transport, though a non-pharmaceutical entity, in considerations of the management of pandemics.

A significant ‘add-on’ to transportation in the management of pandemics was birthed by the introduction of drones. Drones have exceptional delivery systems with huge benefits. They provide unparalleled assistance to manufacturers by helping them meet up with demands, the supply of which would be otherwise impossible given temporal and spatial inhibitions. Particularly, drones demonstrate crucial indispensability in helping emergency products to be available as and when needed. A good case in point is how China employed drones in conveying quarantine materials and medical samples at a time the COVID-19 pandemic was at its peak and movements were highly restricted. The intervention drastically reduced the chances of contact between healthcare workers and medical samples. Besides, the speed of delivery was enhanced by some 50% relative to conventional transportation modes, specifically by road [14].

According to Baker [2], drones delivered COVID-19 tests in Ghana in 2020. Ilancheran [24] and S&P Global [43] also submitted that these drones were operated from distribution centres and warehouses. These distribution centres and warehouses have a wide array of medical supplies in stock such that upon receipt of orders, the required products are placed in boxes and dispatched to the appropriate destinations using drones. In addition, some drone operators have drone stations set up near medical facilities to facilitate fast and secure transportation. Although many of the drones currently employed in developing countries, as well as their technology, originate from developed countries, arrangements have been made to implement the requisite aerial drone technology in developing countries. This has led to the creation of new markets in these developing countries in partnership with stakeholders

including private operators, organizations and governments. Although the use of drone technology to this end has been observed to be relatively slow among developed countries, it is only due to issues that relate to security risks and the limited sensing technology currently in the drone delivery market.

Acknowledging the role drones play in medical supplies logistics, some international logistics companies have started active collaborations with people in the business of drone operation and logistics. UPS, DHL and FedEx are examples of such logistics companies. They formed a kind of tripartite business arrangement with drone companies/operators and manufacturers for the supply of medical products and test samples. This way, they improved laboratory logistics and enhanced delivery lead times. Consequently, names like *Parcelcopter* and *Wingcopter* have emerged in the delivery of emergency medicines and blood supplies, temperature-sensitive medicines together with its temperature-controlled storage unit, non-prescription medicines to consumers, specimens to the lab for testing, emergency blood supplies, and critical drug products and vaccines in locations across Rwanda, Ghana, Tanzania and the USA [15, 33, 53, 57].

Drones are aiding transportation and revolutionizing the supply chain of essential medical supplies even to remote areas of the world. Usually, they are the best mode of transportation for the conveyance of essential products within the shortest possible time, especially where road transportation systems are barely functional or during peaks of ravaging pandemic outbreaks when time is essential to the delivery of samples to laboratories. Thus, the adoption of drones as a crucial logistics solution for enhanced efficiency in the healthcare system is not only desirable but also indispensable, as it could boost cold chain solutions and improve the overall supply chain [53, 57].

Furthermore, beyond the logistics benefits of transport in pandemic control and management, its operations go a long way in creating a safe environment for travellers. Ordinarily, responsible transport would suffice as both a proactive and reactive measure against pandemics. Responsible transport, a new concept in transportation, was advanced by Budd and Ison [8] for a post-COVID world. The conscious and intentional role of individual responsibility is underscored towards the achievement of positive personal/individual, social/corporate and environmental outcomes to checkmate the spread of pandemics and other global public health crises. According to Budd and Ison [8], as an example of a pandemic, COVID-19 has helped identify the role of the individual, collective and political responsibility and actions in the fight against a global menace. Although international organisations and governments at various levels have risen to the occasion by formulating and executing practicable policy responses, it is the collective actions of individuals that have invariably been the most significant and have yielded the most far-reaching positive and impressive desirable outcomes. All over the world, millions of individuals imparted and empowered with the right knowledge and responsibility to protect both their health and that of those around them have responded positively by protecting and isolating themselves as required. Often, this came at significant personal, social and financial costs.

COVID-19 has successfully placed the onus to be responsible on the shoulders of every individual. Such simple routines that could enhance transport safety as maintaining social distance, washing of hands or using a hand sanitizer, travelling when and only when absolutely necessary, steering clear of co-passengers whose health status is unknown, wearing face masks and gloves, and cutting down on discretionary trips, among other safety measures, have reinforced the gospel of responsible transport. Another measure consists in putting safety ahead of the gains of travel demand management. For instance, as found by Padmanabhan et al. [39], a reduction was found in shared biking in New York, Boston and Chicago as COVID-19 cases

increased. This accentuates the imperativeness of taking personal responsibility in transport demand. Beyond these, responsible transport entails considering whether the transport can be substituted for telecommunications, considering the impact travel choices have on trip-makers towards health and wellbeing.

Studies have shown that the risk of disease transmission can be significantly reduced by not only adhering to clinical control and prevention guidelines but also by observing non-pharmaceutical transport protocols. Also established is the significance of collaborations between public health sectors and transport authorities towards proactively formulating and enforcing preventive measures against pandemics. For example, airport and public health officials have a way of addressing the major challenges militating against the efforts of aviation authorities to drastically reduce the transmission rates of infectious diseases. Towards keeping stations/terminals and vehicles safe, many transport authorities in charge of airports, seaports, bus stations, and train stations conscientiously maintain painstaking procedures for medical interventions to prevent the spread of communicable diseases from carriers to fellow passengers, crew members and other staff members [35].

Moreover, while research has shown that restrictions on both domestic and international travels if applied early enough, can be effective in the control of the spread of communicable diseases, it has also been established that, at an advanced stage of any pandemic, behavioural changes become non-negotiably crucial in checking the transmission [12, 32]. This is because passengers often stay close to one another when in concourses, when they use stairways and doorways, and when they pass through checkpoints. More so, deliberately and/or on reflex, they touch many different surfaces while accessing the different stages of the transport service, for example, when using ticket vending machines, lifts or escalators, waiting areas, restaurants, sanitation facilities, and seating queues. They also touch handrails, handles, barriers, waste bins and several other objects.

It has been found that some viruses can thrive for a relatively long time on a range of surfaces, with some of them being able to stay on for up to several days. This period is enough for passengers to be at risk of infection. Therefore, every type of vehicle used for commercial purposes during pandemics is expected to be sterilized for the transmission chain of viruses to be broken. Ideally, an integrated hygiene programme is implemented in all transport hubs with a focus on three major areas (surface, hand and air) to prevent the spread of viruses and germs. Surface and hand hygiene are concerned with disinfecting common touchpoints and the provision of solutions, as well as sanitisers for added protection in the washroom, respectively, while air hygiene takes care of purification and filtration [61]. All these steps are safety measures against transmission.

Furthermore, the possibility of virus transmission among mass transit users and operators may be significantly slashed by simply observing the guidelines stipulated by national public health agencies and other mode-specific regulations. Regarding bus services, these may include coordinated loading and offloading measures, the enforcement of nose masks and face coverings, the use of bus assistants, as well as structural retrofitting and design modifications for existing and future buses, respectively. Finally, applicable and adaptable control measures obtainable in similar mass transit modes for shielding passengers from contracting viruses could also be found practicable for adoption in buses. Such measures could be summarily considered for incorporation without delay [1].

4. TRANSPORTATION-RELATED CHALLENGES IN PANDEMIC CONTROL AND MANAGEMENT

Theoretically, given strict and conscientious adherence to all non-pharmaceutical protocols, especially through responsible transport, transportation could effectively guard against the transmission of pandemics. Also, its task concerning the control and management of pandemics could be less daunting given favourable circumstances. The reality, however, is that transportation as a sector is dogged by a myriad of challenges that constrains its efficacy in pandemic control and management.

According to Bird et al. [6], one of the biggest challenges facing transportation, especially in cities of developing countries, consists in the ownership structure of public transport. In most cities, public transport is largely informal and mostly private owned, thereby making it quite difficult to enforce pandemic-compliant measures or responsible transport protocols. For example, on average, seven of every ten commuters in Nairobi (Kenya) travel to work using matatus (minibuses) that are private owned and operated. Millions of travellers in the city rely solely on this and other informal public transport modes such as minivans, taxis and scooters for their non-active travels. The reason for this is that these informal modes characteristically offer a wider range of reliable transport services to travellers than the formal system. Since the informal services are largely beyond the state's control, it is practically difficult for the government to impose or demand pandemic-responsive or responsible transport measures. Similarly, experiences from South Africa show that many operators of informal minibuses disregarded and resisted attempts by the government to impose capacity regulations. The operators argued that responsible transport measures would paralyze their livelihood and subject them to a life of penury. Meanwhile, imposing penalties such as service suspension and/or reduction on these minibus operators might push them out of business permanently [6]. This has serious implications for public transport even beyond the periods of pandemics.

Another major challenge militating against the seamless adoption of responsible transport measures is widespread apathy on the part of passengers in the observance of the protocols. This apathy mostly manifests in their aversion to regimented hygiene and antipathy towards vaccination. For instance, viral scepticism and misgivings have greeted every attempt made by national and international agencies toward COVID-19 vaccination in many parts of the globe. Granted, conspiracy theories have significantly contributed to the development; however, the fears expressed by the people, especially the blacks and other racial minorities, are necessarily not far-fetched. Empirical evidence and historical records abound that in many cases of medical apartheid, black people and racial minorities have been used as guinea pigs and lab rats for many generations in the past [11, 18, 21, 29, 49, 55].

A good case in point is the Tuskegee Syphilis Study, which has for a long time remained a handy reference point in discourses on how the present-day African-Americans should relate with the biomedical community. Several reports argue that the Tuskegee Syphilis Study is the major reason that informs the position taken by many African-Americans whenever they are involved with institutions of medicine and public health. Thus, naturally, many of them would never totally trust the intentions of these institutions on any issue, no matter how well packaged as being in the best interest of public health. Meanwhile, this lack of trust predated public revelations concerning the study [17, 48], and it subsists still [13, 22, 25, 50, 55].

Moreover, the influence of faith and religion as well as sheer obduracy cannot be ruled out, especially in Africa. It is not uncommon to hear such faith-induced declarations as 'I'm covered by the blood of Jesus', 'None of the ailments of the Egyptians shall touch me', 'My Jesus is bigger than coronavirus', 'I shall not die', 'I shall live to declare the good works of

the Lord…', 'The COVID-19 vaccine contains the DNA of Lucifer!' and 'It is the mark of the Beast!', among other confessions and assertions, especially among professing Christians. Even many Africans who do not exude any religious inclination speak plainly about their abhorrence to COVID-19 vaccination. What seemed to have fuelled this trend is the prediction credited to Melinda Gates. In an interview with the Cable News Network (CNN) in 2020, she had warned, when expressing her concerns over the poor state of African cities and their inadequate healthcare facilities, that there would be dead bodies all over the streets of Africa owing to the scourge of COVID-19 [34]. Later, her partner and erstwhile husband, Bill Gates, fanned the flames by passing a comment that he did not know why COVID-19 cases and deaths were low in Africa as against the grim casualty figures in developed countries [45, 46]. He was unsparingly lambasted over this, though [46], and the resistance against COVID-19 vaccination among Africans seemed to increase with many people claiming that the Gates were up to no good about the COVID-19 vaccine. This is despite decades of their enormous financial commitments to health issues in Africa.

Unsustainable livelihoods and poverty constitute another major threat to responsible transport in Africa. People with low incomes, especially those who engage in informal sector economic activities, tend to prioritize their livelihoods over life and safety. In an unpublished study by Olojede [37], it was discovered that commercial transport operators in Ile-Ife (Nigeria) would rather contract COVID-19 than starve owing to the suspension of their services brought about by lockdowns. The commercial transport operators accused politicians and community leaders of hoarding palliatives meant for them during the lockdowns and concluded that they would be better off with the COVID-19 infection risks for as long as they could earn their daily bread unrestricted.

Furthermore, despite their huge role as a key complement with great potential for substituting conventional transportation modes in terms of supply chain efficiencies, drones also have their limitations. Granted, their use has removed many hurdles; yet, safe delivery of vital medical interventions would be difficult if careful and proper advance planning is not put in place. Consequently, there is the need for a highly skilled workforce whose duty should be to maintain a seamless logistics management of information systems during pandemics. Moreover, delivering efficient interventions involves overcoming extremely complicated logistic and programmatic impediments that could come up at any point along the supply chain. Ensuring all these may prove overwhelming to many African and other developing countries owing to corruption, poor management and other human factors.

5. WAY FORWARD: INTEGRATING PANDEMIC-RESPONSIVENESS IN TRANSPORTATION SYSTEMS

Towards consolidating on the strengths of the transport sector in the control and management of pandemics and other public health issues, integrating the fundamentals of responsible transport and/or pandemic-responsiveness into the transportation systems, particularly in developing countries, is non-negotiable. Consequently, practicable policy recommendations are hereby proffered.

First, governments should demonstrate a sincere commitment to the good of public transport investment. Given that the government is not a major stakeholder in the transport sector, its intervention would always be taken as an imposition, which may be opposed by the investors and operators in the sector. Thus, a joint ownership in the form of public-private partnership (PPP) arrangements should be considered in the transport sector's ownership

structures. This would go a long way in enlisting the support of transport investors and operators whenever there is a need for the implementation of expedient measures such as responsible transport protocols.

Equally, a dedicated commitment to non-motorized transport infrastructure investments and inclusive urban design is crucial to reducing the risks of dispensable motorized or public transport demand during pandemics. As important as active transport is, studies have found that its facility investment is hardly prioritized in many developing countries yet [30, 38], investing in walkways, footbridges, cycle infrastructure, and street lighting is a significant way of maintaining accessibility [6]. Efforts should be made towards ensuring their integration.

Another relevant aspect of active transport is the need for public education and enlightenment. In many African societies, active transport is generally seen as the lot of the poor and wretched [38]. Pedestrians and bicyclists are naturally viewed as underdogs socioeconomically, thus rarely respected. The only reason many Africans take active transport modes is that they cannot afford private cars [31, 38]. They should be reorientated to realize that active transport is sought after by wealthy and smart-enough people in developed countries for its time-honoured health benefits. Its indispensability to the realisation of responsible and pandemic-responsive transport should also be emphasized.

In addition, transparency of policies and medical research procedures is sacrosanct. Governments all over the world should learn to prioritize building confidence and trust in people. No matter how laudable transport policies are, once the motive behind them is doubted by the people, such policies would be dead on arrival. In the same vein, medical research should be conducted transparently and ethically, especially when black people and racial minorities are involved. It is quite difficult, if not impossible, to erase history and the extent of the influence it wields on both the present and the future.

Of course, no matter how good, transparent and effective transport policies during health emergencies can be, some people would choose to be recalcitrant; hence, the need for relevant legislation. Legislation is an effective tool to tackle this form of challenge, particularly when there is strict enforcement. For example, a jail term of just one day without the option of a fine would be effective in making a typical African law-abiding. Anything about imprisonment is both a shame and an anathema to real Africans. It would work. However, care should be taken not to abuse the legislation towards achieving draconian, suppressive or unpopular goals.

Moreover, it is apparent that virtual activities complement transportation. This is especially so at critical stages of pandemics. Therefore, deliberate massive investment should be made in supporting critical urban infrastructure. In countries where electricity and internet connection are a privilege or obtained at prohibitive costs, virtual activities would not be feasible. In addition, since not all trips can be substituted, essential travels are unavoidable. When made, the gains of such nondiscretionary trips should be optimized for reducing the trip length and trip frequency through trip chaining. Research has shown that consolidating trips can be viewed broadly within the paradigm of the concept of bounded rationality, as people respond to changes by pursuing several activities along a single trip chain to achieve travel economies [38].

6. CONCLUSION

Having redefined the relationship between transportation and pandemics as one that covers not only transmission but also extends to control and management, this paper duly acknowledges responsible transport as being rich in non-pharmaceutical protocols against

pandemics. The challenges militating against responsible transport were also highlighted. To enhance pandemic responsiveness of future transportation systems, practicable policy recommendations were suggested for the modification of transport demand, systems, operations, and administration. Granted, there may be yet no known way of absolutely forestalling pandemics in the future; nevertheless, if the recommendations herein are carefully considered and favoured for adoption, the scourge of future pandemics will be considerably undermined. Thus, transportation will take its place of pride and never again be relegated among pandemics' control and management solution options.

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