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Mpox person-to-person transmission – Where
have we got so far? A systematic review

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UNIVERSIDADE DO PORTO**

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Faculdade de Medicina da Universidade do Porto, 15 / 03 / 2023

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DESIGNAÇÃO DA ÁREA DO PROJECTO

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Mpox person-to-person transmission: Where have we got so far? A systematic review.

ORIENTADOR

Carmen Maria Lisboa da Silva

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É AUTORIZADA A REPRODUÇÃO INTEGRAL DESTES TRABALHOS APENAS PARA EFEITOS DE INVESTIGAÇÃO, MEDIANTE DECLARAÇÃO ESCRITA DO INTERESSADO, QUE A TAL SE COMPROMETE.	☐
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Faculdade de Medicina da Universidade do Porto, 15 / 03 / 2023

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À minha orientadora, pela paciência e pela inesgotável dedicação. Sem ela este trabalho não teria sido possível. Ao André e à Catarina pelos conselhos e suporte diário. Aos meus pais e à Filipa por estarem sempre presentes.

Mpox person-to-person transmission – Where have we got so far? A systematic review

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Abstract: The recent multi-country outbreak of Mpox (Monkeypox disease) constitutes a public health emergency. Although animal-to-human transmission is known to be the primary way of transmission, an increasing number of cases transmitted by person-to-person contact have been reported. During recent Mpox outbreak sexual or intimate contact has been considered the most important way of transmission. However, other routes of transmission must not be ignored. The knowledge on how the Monkeypox Virus (MPXV) spreads is crucial to implement adequate measures to contain the spread of the disease. Therefore, this systematic review aimed to collect scientific data published concerning other implicated sources of infection beyond sexual interaction, such as the involvement of respiratory particles, contact with contaminated surfaces and skin-to-skin contact. The current study was performed using the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Publications analyzing contacts of Mpox index cases and their outcome after contact were included. A total of 7235 person-to-person contacts were surveyed and 252 of them became positive cases. Positive secondary transmission of MPXV was verified after contact with people cohabiting in the same household, with family members, with healthcare workers or within healthcare facilities, and sexually or with contaminated surfaces. Using the same cup, sharing the same dishes, and sleeping in the same room or bed were also positively associated with transmission. Four studies showed no evidence of transmission despite contact with surfaces, skin-to-skin contact or through airway particles within healthcare facilities where containment measures were taken. These records support person-to-person transmission and suggest that other types of contact beyond sexual contact compose significant risk to acquire the infection. Further investigation is crucial to elucidate MPXV transmission dynamics and to implement adequate measures to contain the spread of the infection.

Keywords: Mpox, Monkeypox, transmission, sexual, skin, surfaces, fomites, respiratory

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1. Introduction

Mpox (Monkeypox disease) is a zoonotic infectious disease established in humans characterized by rash, fever, skin lesions, lymphadenopathy, headache, upper respiratory symptoms, oral ulcers, vomiting and conjunctivitis [1]. This disease is caused by the Monkeypox Virus (MPXV), a virus that belongs to the genus *Orthopoxvirus* and the family *Poxviridae* [2]. Although this virus was originally found in animals, it was firstly identified in humans in 1970 in the Democratic Republic of the Congo [3]. Mpox is an endemic disease

in some regions like West and Central Africa, where two different clades of the virus have been identified [4], clade I (formerly known as Congo Basin/Central African clade) and clade II (formerly known as West African clade). To our knowledge, human MPVX infection transmission from infected exotic pets was identified for the first time in the United States in 2003 [5]. However, Mpox became a world concern when, in 2022, a high number of cases were identified in several nonendemic countries such as Portugal, Sweden, Spain, Italy, France, Germany, Netherlands, and Belgium [3], with the first case being reported on May 7, 2022 in the United Kingdom [3].

Animal-to-human transmission is known to be the principal mode of transmission. In fact, several studies support this assumption and have stated that, initially, the virus might have infected humans after contact with animals [6]. However, human-to-human transmission has also been described during outbreaks occurring in endemic regions. The recent outbreak among countries in the WHO (World Health Organization) European region and USA highlights that human-to-human transmission of MPXV through sexual or intimate contact might be the predominant mode of Mpox transmission, mainly because the majority of infected patients were men who had sex with men [7]. Nevertheless, it is important to unveil other routes of Mpox transmission, since the risk of infection is not limited to sexual networks between men and not all individuals that are infected share a recent history of sexual contact [1]. In this regard, the contact with infected respiratory droplets, with skin lesions of other patients or with surfaces and fomites must not be underestimated. The knowledge on how this virus spreads is fundamental and is crucial to implement adequate measures to contain the spread of the disease, accordingly to its transmission.

This systematic review aims to summarize the evidence associated with the human-to-human transmission of the MPXV, and other sources of infection beyond sexual transmission, like the involvement of respiratory particles, the contact with contaminated surfaces and skin-to-skin contact.

2. Materials and Methods

2.1. Protocol

This systematic review was conducted based on the recommendations presented on Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines [8].

2.2. Eligibility Criteria

To access the evidence on transmissibility associated with the MPXV, we included articles referring to human-to-human contact, case reports, observational studies and other systematic reviews. Articles meeting the following criteria were eligible for inclusion: (1) studies concerning people who contacted with cases of Mpox and (2) whose outcome after contact was evaluated. There were no restrictions on language or related to the date of publication of the articles. Publications were searched and included until 1 November 2022. Articles addressing animal-to-human or human-to-animal contact, vertical transmission, literature reviews, case reports and editorial articles were excluded.

2.3. Information Sources and Search Strategy

A systematic search was carried out in PubMed, Scopus and Web of Science on 1 November 2022. The queries used are presented in Table 1 (Supplementary File S1) and included the terms “monkeypox”, “transmission”, “transmissions”, “transmissibility”, “transmissible”, “clothing”, “clothes”, “contact”, “surface”, “surfaces”, “fomite”, “fomites”, “particle”, “particles”, “sexual”, “mucous”, “contaminated”, “contamination”, “respiratory”, “skin”, “skin-to-skin”, “humans” and “human”.

2.4. Study Selection

Two independent researchers (P.P. and M.A.C.) selected the articles one by one for inclusion or exclusion based on title and abstract. The conflicts were solved by a third researcher (C.L.). The full text of the resulting articles was analyzed by two researchers, who selected independently the articles for inclusion. Once more, potential conflicts were discussed and solved by a third author.

An online program (Covidence systematic review software, Veritas Health Innovation, Melbourne, Australia) was used to remove duplicates and to conduct the screening of the articles and find the ones eligible for full text analysis.

2.5. Data Collection Process

Three authors (P.P., M.A.C. and M.F.M.G.) extracted information independently from the included articles and reached consensus for data inclusion. Data extraction was conducted using Microsoft Word software and predefined tables. The following information was collected from each included study: author, year of publication, study design, setting data, case definition, type of contact/mode of transmission, index case(s), contacts (possible), secondary cases, conclusion and limitations.

2.6. Study Quality Assessment

The risk of bias was evaluated using the quality assessment tool from the National Institutes of Health, which allowed us to classify the studies into poor, fair or good quality depending on the fulfilment of criteria defined by this tool [9]. This assessment was per-formed by M.A.C., M.F.M.G., and C.L. Divergences resulting from this process were dis-cussed between the authors.

3. Results

3.1. Number of Retrieved Papers

A total of 1115 articles were found in our first research on the 3 databases, 417 of which were duplicated. Out of 698 articles, 635 were excluded after analysis of title and abstract and 63 were included for full-text analysis. We further excluded 50 articles considering inclusion and exclusion criteria and a final number of 13 observational studies were included in this systematic review: 4 retrospective cohorts and 9 prospective cohorts. These results are summarized in Figure 1.

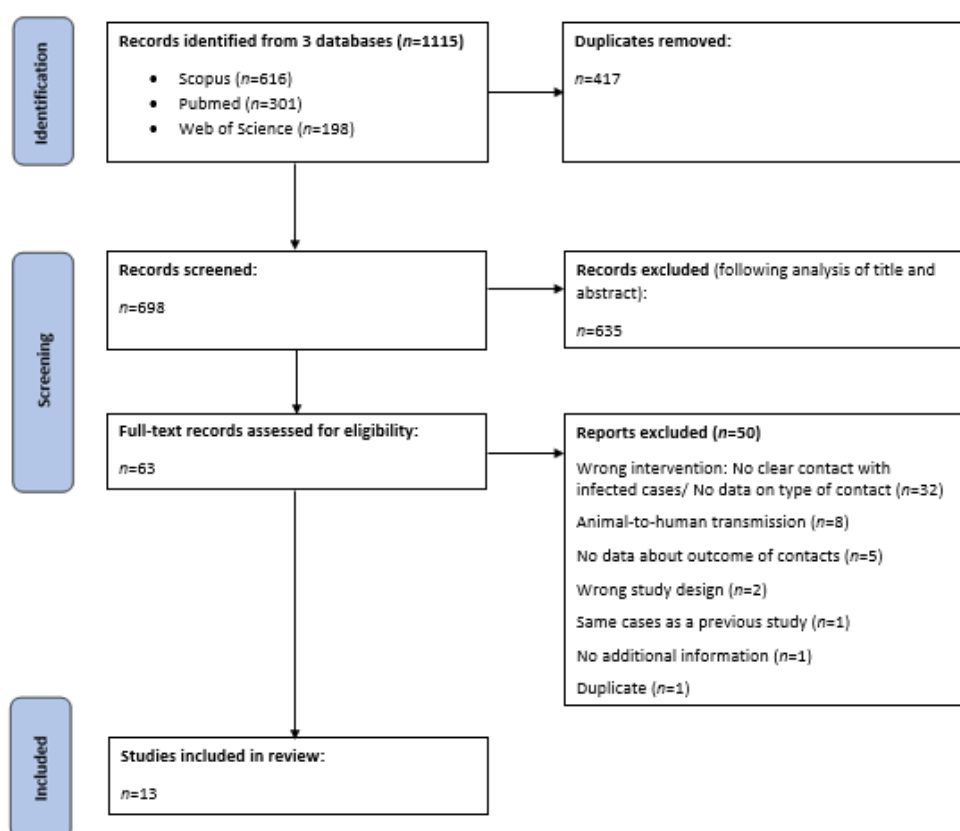


Figure 1. Flow chart of study selection.

3.2. Study Characteristics

This systematic review included 13 studies [10–22] (Table 1): 7 studies were from Africa [10–13,15–17], 6 of which from Zaire, now called Democratic Republic of the Congo [10–13, 16], 3 studies from the USA [14,21–22], 1 from Singapore [18], and 2 studies from Europe, respectively from United Kingdom and Spain [19,20]. Ten studies were published before 2022 [10–19] and the remaining 3 were published in 2022 [20–22].

Table 1. Characteristics of the 13 included studies.

Authors, Year	Type of study	Setting Data	Case Definition	Type of contact/Mode of transmission	Index cases	Possible contacts	Secondary cases	Conclusions	Limitations	Quality Assessment ¹
Arita et al. [10]	Retrospective cohort (observational)	West and Central Africa 1970–1983 Data included are from Zaire	Clinical, epidemiological and laboratorial diagnosis	Person-to-person	--	Household: 708 Vaccination scar: 566 No vaccination scar: 142 Other: 945 Vaccination scar: 710 No vaccination scar: 235	Household: 25 Vaccination scar: 3 No vaccination scar: 22 Other: 6 Vaccination scar: 0 No vaccination scar: 6	The attack rate for household contacts was significantly higher than that for other contacts	No data on how surveillance of contacts and cases was done No case definition.	Poor
Jezek et al. [11]	Retrospective cohort (observational)	Outbreak of five children of human MPXV belonging to 2 families West Kasai, Zaire May–July 1983	Clinical diagnosis + Serological test: 1 case Virus isolation from skin lesion: 3 cases	Person-to-person	1 index case (animal-to-human) Initiated a cascade of transmission that ended up on 4 secondary or tertiary infected cases.	Household: 17 Vaccination scar: 6 No vaccination scar: 11 Other: 22 Vaccination scar: 2 No vaccination scar: 20	Household: 3 Vaccination scar: 2 No vaccination scar: 1 Other: 1 Vaccination scar: 1 No vaccination scar: 0	Epidemiologic investigations of the 5 children suggest that the 1st case was infected from an animal source, and the other 4 cases were infected from a previous human case	No case definition. Possibly, the same cases are reported by Arita et al. [10].	Poor
Jezek et al. [12]	Prospective cohort study	Evaluation of transmission to 2,510 contacts of 214 patients Zaire 1980–1984	Confirmed case was one in which the clinical and epidemiological diagnosis of human MPXV was confirmed by laboratory findings	Person-to-person	214 cases primary cases: 152 secondary cases: 62	Household: 1,187 Vaccination scar: 910 No vaccination scar: 277 Other: 1,323 Vaccination scar: 959 No vaccination scar: 364	Household: 48 Vaccination scar: 14 No vaccination scar: 34 Other: 14 Vaccination scar: 2 No vaccination scar: 12	The attack rate for household contacts was significantly higher than that for other contacts, among both unvaccinated (4 times higher) and vaccinated (7 times higher) household contacts	Few of the vaccinated contacts were tested serologically to determine subclinical infection. Possibly, the same cases are reported by Arita et al. [10].	Good
Jezek et al. [13]	Prospective cohort study	Evaluation of transmission from 338 patients Zaire 1981–1986	A patient having onset of rash between 1 and 3 weeks after exposure to an index case is a secondary case, which may have arisen by person-to-person transmission. Confirmation by laboratory findings	Person-to-person	338 cases primary cases: 245 secondary cases: 93	Household: 1,420 Vaccination scar: 989 No vaccination scar: 431 Other: 858 Vaccination scar: 566 No vaccination scar: 292	Household: 53 Vaccination scar: 13 No vaccination scar: 40 Other: 16 Vaccination scar: 2 No vaccination scar: 14	The affected households appear to be the most important focal point for dissemination of MPXV to susceptible individuals	Possibly, the same cases are reported by Jezek et al. [12]	Good
Fleischauer et al. [14]	Prospective cohort study: analysis of exposure	Evaluation of MPXV infection in HCWs who were within	Serological studies were done. Presence of fever or rash with at least 2 other	Person-to-person	Hospitalized patients: 3	HCWs contacts: 57 Vaccination: 31 No vaccination: 26 Gloves: 35	Symptoms: 0 Both IgG and IgM positive: 0	Transmission not verified in healthcare facilities	Potential selection bias (the participation rate in hospitals A and B was different)	Fair

	of HCWs to hospitalized infected patients	a radius of 2 meters from 3 infected patients USA/Indiana 2003	symptoms, including chills, headache, backache, lymphadenopathy, sore throat, cough, and shortness of breath			Gown: 19 Surgical mask: 14 N95 mask: 11 Surfaces/ fomites: 46 Airway particles: 52 Skin-to-skin: 28 Out of 57 HCWs, 40 (70%) had ≥ 1 unprotected exposure	Just IgM: 1, was vaccinated in the last 6 months. 1 positive IgM, (asymptomatic)	A control group was not used to test the accuracy of ELISA test – there is the potential of some false positive tests. Potential reporter bias - difficulty to recall		
Learned et al. [15]	Retrospective Cohort	Cascade of six sequential transmissions in a hospital and between people belonging to the same family, almost all with less than 18 years old. Democratic Republic of the Congo 2003	Suspect and probable case – meets both epidemiological and symptomatic (fever or rash if suspect, both conditions if probable) criteria Confirmed case – meets epidemiological, symptomatic and laboratory (virus in culture, PCR or immunohistochemical) criteria	Person-to-person	Index case: 1 Initiated a cascade of transmission that led to 11 more secondary cases: 1 suspect 7 probable 3 confirmed <u>Type of contact:</u> Household visitor: 1 (also owned a pet monkey, in good health) Hospital contact with a case: 3 Intrafamilial contact with a case: 2 Both intrafamilial and hospital contact: 4 Not specified: 1	--	Surveillance was not done among exposed HCWs. However, none got symptoms.	Identified 11 clinical cases of secondary MPXV infection spread over 6 waves of person-to-person transmission. Transmission verified in healthcare facilities between patients, where control measures were not present. The primary infected people were children (less than 18 years old) After control measures were taken, no more cases were identified. No access to protective equipment (gloves, masks...).	No data on vaccination Healthcare workers must have been spared because of previous vaccination	Poor
Nolen et al. [16]	Retrospective cohort study	Identification of specific activities and behaviours potentially associated with an increased risk of MPXV transmission within 16 household Democratic Republic of the Congo 2013	Clinical diagnosis or PCR (Cases that were not confirmed by PCR were based only on symptoms)	Person-to-person	Primary cases 17	Household Total: 97	MPXV symptomatic contacts: 44 (22% vaccinated) Positive Correlation: Drinking from the same cup Eating from the same dish Sleeping in the same room Sleeping in the same bed Negative Correlation: Laundering clothes Kissing Assisting with toileting and hygiene	Risk factors of acquiring MPXV in a household included sleeping in the same room or bed or using the same plate or cup as the primary case. Activities associated with an increased risk of MPXV transmission all have potential for virus exposure to the mucosa.	Only 30% of the cases were confirmed by PCR. Possibility of immunity because of previous infection with MPXV.	Fair

Besombes et al. [17]	Prospective cohort study (observational) analysis of exposure of contacts to an index case	Intrafamily transmission on a family from an index case Central African Republic 2018	Clinical diagnosis + laboratory confirmation (PCR)	Person-to-person	Index case (animal-human-transmission): 1 Intrafamilial contact (confirmed by PCR): 5 Case-patient's daughters: 2 Case-patient's sisters: 2 Case-patient's sister-in-law: 1	HCWs contacts: 2 Other case patients' family: 5 Case-patient's village contacts: 31 Close contact: 27	Total: 6 cases Positive by serological test (all asymptomatic) HCWs: 2 (1 vaccinated) Other case patients' family: 3 (1 animal contact and vaccinated) (1 vaccinated) (1 no animal contact, not vaccinated) Case-patient's village contacts: 1	Identified 5 clinical cases of secondary MPXV infection spread over 3 waves of intra-familial infection, originating from an index case patient with primary infection possibly attributable to contact with wild fauna. Positive serologic findings in healthcare workers highlight the limited infection prevention and control resources, to protect HCWs responding to outbreaks in Central African Republic	No data about the kind of intrafamily transmission. No data about HCWs protection.	Poor
Kyaw et al. [18]	Prospective cohort study (observational) analysis of previous contacts of index cases	HCWs who were in contact with a case of MPXV, before admission to the isolation unit Singapore 2019	Clinical diagnosis	Person-to-person	Hospitalized patient: 1 traveller who had recently returned from Nigeria (probable animal to human transmission)	Direct contact with the patient himself or the patient's surrounding: 12 Surfaces/fomites (handled the patient's linen and cleaned the NEP room): 3 Laboratory staff who had handled the patient's specimens: 12 All had protected exposure to the patient, with the appropriate and adequate use of PPE.	All asymptomatic	Clear infection prevention guidelines on the appropriate PPE for different HCWs, based on patient care activities and the transmission risk are crucial	HCWs used protection like gloves and face masks while contacting with the patient, so results must be biased. No lab confirmation that 27 HCWs had MPXV infection. No sampling of objects or surroundings of the index case patient	Fair
Vaughan et al. [19]	Prospective cohort study (observational) analysis of contacts of 1 HCW	HCW who contact with a case of MPXV infected from Nigeria United Kingdom 2018	Clinical diagnosis	Person-to-person Direct exposure of skin lesions, body fluids, including clothing or bedding without wearing appropriate PPE	Hospitalized patient: 1 traveller who had recently returned from Nigeria	134 Adequate protective measures were taken (gown, gloves, face shield)	4 became ill	The use of standard PPE may not have afforded sufficient protection against MPXV particularly if skin lesion debris containing virus had been disturbed and inhaled when bed-sheets were changed. The risk to the public was very low because effective human-to-human transmission requires close contact with an infected person or virus-contaminated materials	No serology tests. No data on previous smallpox vaccination. Post-exposure vaccination to MPXV could have inhibited disease.	Fair

Aguilera-Alonso et al. [20]	Prospective cohort study	Pediatric population (n = 16) Aged 7 months to 17 years old Spain, 2022	Clinical diagnosis + laboratory confirmation (PCR)	Total: 16 positive cases			--	Either sexual, contact with contaminated material in a tattoo studio or household contact with parents caused infection. Sexual contact does not explain all infections by MPXV.	Data collected by epidemiological surveys based on interviews with patients and their family members.	Poor
				Sexual	3 (aged 13 – 17 years old)	--				
				Surfaces/fomites (contaminated material in a tattoo and piercing studio)	9 (aged 13 – 17 years old)	--				
				Household (contact with their parents: 3)	3 (age inferior 4 years old)	--				
				Unknown	1 (age inferior 4 years old)	--				
Hagan et al. [21]	Prospective cohort study	Contacts with a confirmed case in a jail Clade: West African USA/Chicago 2022	Clinical diagnosis, serologic test or both	Person-to-person but no sexual/skin-to-skin contact	1 resident	57 residents (22 lost follow-up) 35 residents completed follow-up (Mask usage is probably low)	Symptoms + serologic testing for only 14 residents that consented to testing IgM positive: 0 IgG positive: 3 (asymptomatic)	No evidence of skin-to-skin or sexual contact among residents. No secondary cases were identified.	Difficult quantification of exposure risk	Fair
									Out of 57 potentially exposed, only 35 completed follow-up.	
									Out of 36 potentially exposed, only 13 accepted post exposure prophylaxis; only 14 accepted testing.	
									3 IgG positive probably because previous vaccination	
									Serologic testing performed 7 days after potential exposure for some residents, when they might not yet have seroconverted.	
Marshall et al. [22]	Prospective cohort study	HCWs exposed to 55 patients with MPXV	Surfaces/fomites	Total: 55 patients	Total: 313 HCWS 12% received postexposure vaccine. N=26 HCWs	Presence of symptoms: 7	No HCWs developed an MPVX infection during the 21 days after exposure.	Self-report of symptoms/sexual contact	Selection bias – these results must not be generalized to the community population.	
								Not able to confirm childhood smallpox vaccination history		

USA/Colorado 1 May – 31 July, 2022	Clinical diagnosis + laboratory con- firmation (PCR) in two people	Airway par- ticles (Aerosol- generating procedures) Skin-to-skin	Glove use: 23 No glove use: 3 Unknown glove use: 0 N=7 HCWs Mask use during the pro- cedure: 3 N=161 HCWs Glove use: 125 No glove use: 30 Unknown glove use: 6	2 people who had rash or lesions (n=3) per- formed a PCR test: all negative	Infection prevention training is important in all healthcare settings, and these findings can guide future updates to PPE recommendations and risk classification in healthcare settings.	Data related to previous vac- cination is lacking. Lack of information about ex- posure to contaminated mate- rials. Lack of information about the use of facemasks by patients.
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--: Not mentioned; MPXV: Monkeypox virus; HCWs: Healthcare workers; !: Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies.

3.3. Outcome assessment and evidence of contact with MPXV

The clade of MPXV involved was only known in 1 study, which was the West African clade [21]. In 2 studies, the outcome assessment was only clinical [18,19]. The other 11 had, at some point, confirmation by serological findings or virus isolation [10–17,20–22]. All studies reported person-to-person contact with infected patients. A total of 7235 contacts were surveyed, and 252 of them were considered Mpox positive cases. Seven studies reported household contact [10–13,15,16,20], 4 studies reported surface/fomites contact [14,18,20,22], 2 studies reported potential contact with airway particles and skin-to-skin contact [14,22], 2 studies reported intrafamilial contact [15,17], 1 study reported sexual contact [20], 1 study reported direct contact with the patient or the patient's surroundings or specimens [18], 1 study reported person-to-person but no sexual or skin-to-skin contact [21]. Two studies focused on Mpox transmission on pediatric population [15,20].

3.4. Evidence of transmission

Nine studies showed positive secondary transmission of MPXV [10–13,15–17,19,20]. In these, there was evidence of contact with people cohabiting in the same household [10–13,15,16,20], with family members [15,17], with healthcare workers [17,19] or within healthcare facilities [15], with contaminated surfaces [20] and sexually [20]. Drinking from the same cup, eating from the same dish, sleeping in the same room and sleeping in the same bed were positively associated with transmission [16]. Four studies showed no evidence of transmission [14,18,21,22] despite contact with surfaces, skin-to-skin contact or through airway particles in 3 healthcare centers [14,18,21] and one in a prison facility [21].

Data related to the use of mask, gloves or other protective equipment was available in 6 of the 13 studies [14,15,18,19,21,22], 2 of which reported low usage of protective measures [15,21].

3.5. Risk of bias within and across studies

A total of 5 studies were considered to have poor quality [10,11,15,17,20], 6 studies were considered fair [14,16,18,19,21,22] and 2 studies were good [12,13]. The studies with poor quality consequently resulted in low levels of evidence. Participants were lost to follow-up in some studies and others have a very low population size. The same cases were probably present in different included studies, which can result in duplicate information. The usage of gloves and other protective equipment makes somewhat difficult to measure adequately the exposure of contacts. A previous vaccination history could underestimate the risk of transmission to unvaccinated individuals. Outcomes were not always obtained by PCR techniques, having been evaluated only symptomatically, which means that outcome measures were not consistently applied within and across studies. Additionally, the studies are not entirely comparable because they occurred in different places, at different moments in time, and they must be analyzed taking these questions into account.

4. Discussion

Summary of evidence

Although several studies suggested a household transmission of the virus, the type of contact occurring in the habitation is difficult to understand [10–13,15,20]. The transmission of MPXV could be a result from skin-to-skin contact, respiratory particles, sharing the same household surfaces or fomites or intimate contact. For instance, Nolen et al. [16] showed that people who share the same cup and dish, and sleep in the same room or bed are prone to transmit the virus to others. Such outcome corroborates the assumption that MPXV may be transmitted by surfaces or fomites. Nevertheless, activities such as kissing or laundering clothes showed no correlation with acquisition of the virus [16]. Although the type of transmission is not clear, these studies reinforce the possibility of person-to-

person transmission of MPXV. However, it was reported that people who shared the same space with a confirmed Mpox case in a prison facility in Chicago - despite some of them being offered post-exposure prophylaxis - did not reveal positive transmission after contact with the index patient [21]. None of the exposed reported sexual contact with others nor skin-to-skin contact; only reported washing their clothes in communal showers, sharing personal hygiene items or sitting on other's beds [21]. Therefore, additional data on the type of contact between people who live in the same household are needed.

Some studies showed no evidence of transmission of the virus after exposure of healthcare workers to infected patients through potentially contaminated surfaces and fomites, airway particles like during aerosol-generating procedures, skin-to-skin contact [14,18,22], and through handling patient's specimens [18]. The use of protective measures like masks, gloves, and medical gowns by healthcare workers while caring for patients with Mpox can protect themselves from infection [14,18,22]. Nevertheless, transmission to healthcare workers was documented by Besombes et al. [17], in Central African Republic and to other patients in a hospital in Democratic Republic of Congo by Learned et al. [15]. We highlight the importance of educating people and healthcare personnel to prevent infectious outbreaks by strengthening health centers capacity and resources in remote forest areas as well as to learn measures to control the transmission to themselves and others.

Besombes et al. [17] and Learned et al. [15] showed also a positive intrafamilial transmission and a cascade of spread over 3 and 6 waves of person-to-person transmission, respectively, which shows the implication of other types of transmission other than sexual contact: from an index patient to his 2 daughters, 2 sisters and 1 sister-in-law [17] and from at least 2 contacts in a family that ended up being Mpox confirmed [15]. Person-to-person transmission was also verified in paediatric population [20], aged 7 months to 17 years old, which was related to possible sexual transmission, transmission via contaminated material in a tattoo and piercing studio or by contact with their parents.

After the beginning of the recent Mpox outbreak in 2022, a study conducted by Vaughan et al. [23], assessed the current epidemiological situation, based on confirmed cases of Mpox in 36 countries in the European region submitted to the European Surveillance System (TESSy). The authors demonstrated that the majority of MPXV cases were likely to be transmitted sexually. Other cases were described to involve a surface/fomite, non-sexual and non-healthcare related transmission. However, the contact with clear confirmed cases was not possible in this study given that the analyses performed were based on data submitted to TESSy database.

Regarding the transmission through surfaces, 4 studies [24-27] evaluated the presence of MPXV on surfaces in household [24,25], workplace [26] and a hospital environment [27] after a positive case was in close contact with those surfaces. All studies showed high loads of detectable virus on surfaces directly touched by a person with Mpox, and the virus could be present either on porous or nonporous surfaces [24,25]. When the specimens collected by swabbing the surfaces were cultivated on cell cultures (Vero cells), the virus showed to be viable in some specimens in two studies [24,27] and not viable in any specimen in one study [25]. Morgan et al. [24] stated that the virus viability can be maintained for at least a period of 15 days after the contact. Therefore, these results show that MPXV could infect people through contact with surfaces. Although this hypothesis was not confirmed yet, Mpox-specific cleaning, maintaining appropriate hand hygiene and decontamination measures of surfaces should be considered in such situations [25,26]. Nevertheless, additional studies regarding MPXV transmission via contaminated surfaces and objects are crucial since there is still insufficient knowledge on this topic.

Due to lack of data regarding the transmission of MPXV, it is not clear what has changed concerning the transmission dynamics comparing Mpox cases before and after the outbreak of 2022. Although it has been shown that individuals were more prone to acquire infection following sexual contact, we need more clear evidence that clearly states that.

Limitations

This systematic review poses several limitations. Some studies showed low quality or did not mention what type of person-to-person contact played a role in the transmission [10,11,15,17,20]. Moreover, other studies containing only epidemiological data and lacking information on the type of contact between two infected individuals were excluded, which may bias the results. Additionally, the 2022 outbreak is a recent occurrence and thus there is still little information, which does not allow to address the knowledge gaps about Mpox transmission dynamics.

There is also an additional risk of bias in establishing the transmission potential of the virus because some patients received post-exposure prophylaxis [21], while others were vaccinated against MPXV [10–14,17,19,21,22]; in other studies, information about previous vaccination was lacking.

Some of the included articles did not confirm Mpox infection among contacts by detection of MPXV DNA using PCR technique. That can lead to a bias of the results because it is possible that some infected people might be asymptomatic. Some individuals, especially healthcare workers, used protection like masks and gloves while contacting with a positive case. That probably limited the spread of infection, and the results could be biased [13,18,19,21,22]. People might have contacted in different ways at the same time, thus making it difficult to know what type of contact was responsible for infection.

5. Conclusions

The recent outbreak of MPXV still is of great concern. Cases of infection have been reported in several countries, worldwide, and the virus transmission initially started to be mainly by person-to-person contact. This systematic review aimed to clarify the different types of transmission that are established. The findings of this systematic review support that MPXV can be transmitted person-to-person besides sexual contact, by piercing and tattooing, contaminated surfaces, objects, and fomites.

Nevertheless, considering the few studies on Mpox in humans there is a need for improvement in the quality of studies and further investigation focusing on understanding the types of transmission of the virus. It is very important to know how individuals can protect themselves from infection and which precautions are needed. Yet, the use of masks is recommended when in contact with any suspect or confirmed case, especially in healthcare facilities. Activities such as frequent hand disinfection and appropriate surface cleaning are widely recommended.

In future investigation, it is necessary to maintain a good follow-up of case contacts and to establish correctly the type of contact between people. In addition, confirmation of Mpox infection by PCR should be considered in all studies.

Supplementary Materials: The following supporting information can be downloaded at: www.mdpi.com/xxx/s1, Table S1: Queries used for database search in PubMed, Scopus, and Web of Science.

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Anexos

a) Material suplementar – tabela S1

Table S1 – Queries used for database search in PubMed, Scopus and Web of Science

PubMed	Monkeypox[Title/Abstract] AND (transmission[Title/Abstract] OR transmissions[Title/Abstract] OR transmissibility[Title/Abstract] OR transmissible[Title/Abstract] OR clothing[Title/Abstract] OR clothes[Title/Abstract] OR contact[Title/Abstract] OR surface[Title/Abstract] OR surfaces[Title/Abstract] OR fomite[Title/Abstract] OR fomites[Title/Abstract] OR particle[Title/Abstract] OR particles[Title/Abstract] OR sexual[Title/Abstract] OR mucous[Title/Abstract] OR contaminated[Title/Abstract] OR contamination[Title/Abstract] OR respiratory[Title/Abstract] OR skin[Title/Abstract] OR skin-to-skin[Title/Abstract]) AND (humans[All Fields] OR human[All Fields]) NOT (review[Publication Type]) NOT (editorial[Publication Type]) NOT (case reports[Publication Type])
Scopus	(TITLE-ABS-KEY (transmission OR transmissions OR transmissibility OR transmissible OR clothing OR clothes OR contact OR surface OR surfaces OR fomite OR fomites OR particle OR particles OR sexual OR mucous OR contaminated OR contamination OR respiratory OR skin OR skin-to-skin) AND TITLE-ABS-KEY (monkeypox) AND ALL (human OR humans)) AND (EXCLUDE (DOCTYPE , "re") OR EXCLUDE (DOCTYPE , "ed") OR EXCLUDE (DOCTYPE , "no") OR EXCLUDE (DOCTYPE , "ch"))
Web of Science	AB=(Monkeypox) AND AB=(transmissibility OR transmissible OR transmission OR transmissions OR fomite OR fomites OR sexual OR surface OR surfaces OR clothing OR clothes OR mucous OR skin OR skin-to-skin OR contact OR contamination OR contaminated OR respiratory OR particle OR particles) NOT (Book Review OR Database Review OR Editorial Material OR Review (Document Type)) AND (humans OR human (All Fields))

b) Reporting guidelines - PRISMA

Section/topic	#	Checklist item	Reported on page and paragraph/ table #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both. - MANDATÓRIO	Página 1: “Mpox person-to-person transmission – Where have we got so far? A systematic review”
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number. – SEGUIR RECOMENDAÇÕES DA REVISTA	Página 1: “ Abstract: The recent multi-country outbreak of Mpox (Monkeypox disease) constitutes a public health emergency... Further investigation is crucial to elucidate MPXV transmission dynamics and to implement adequate measures to contain the spread of the infection. Keywords: Mpox, Monkeypox, transmission, sexual, skin, surfaces, fomites, respiratory”
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. – MANDATÓRIO <i>O rationale corresponde à justificação da importância da revisão sistemática</i>	Página 2 (parágrafo 2): “Animal-to-human transmission is known to be the principal mode of transmission. In fact, several studies support this assumption and have stated that, initially, the virus might have infected humans after contact with animals [6]. However, human-to-human transmission has also been described during outbreaks occurring in endemic regions. The recent outbreak among countries in the WHO (World Health Organization) European region and USA highlights that human-to-human transmission of MPXV through sexual or intimate contact might be the predominant mode of Mpox transmission, mainly because the majority of infected patients were men who had sex with men [7]. Nevertheless, it is important to unveil other routes of Mpox transmission, since the risk of infection is not limited to sexual networks between men and not all individuals that are infected share a recent history of sexual contact [1]. In this regard, the contact with infected respiratory droplets, with skin lesions of other patients or with surfaces and fomites must not be underestimated. The knowledge on how this virus spreads is fundamental and is crucial to implement adequate measures to contain the spread of the disease, accordingly to its transmission.”
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS). - MANDATÓRIO	Página 2 (parágrafo 3): “This systematic review aims to summarize the evidence associated with the human-to-human transmission of the MPXV, and other sources of infection beyond sexual transmission, like the involvement of respiratory particles, the contact with contaminated surfaces and skin-to-skin contact.”

METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number. – FACULTATIVO	Página 2 (parágrafo 4): <i>“2.1. Protocol</i> This systematic review was conducted based on the recommendations presented on Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines [8].”
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale. – MANDATÓRIO <i>É altamente recomendado, de acordo com as boas práticas da Cochrane, que não sejam aplicados critérios de exclusão baseados na língua e/ou data de publicação dos estudos.</i>	Página 2 (parágrafo 5): <i>“2.2. Eligibility Criteria</i> To access the evidence on transmissibility associated with the MPXV, we included articles referring to human-to-human contact, case reports, observational studies and other systematic reviews. Articles meeting the following criteria were eligible for inclusion: (1) studies concerning people who contacted with cases of Mpox and (2) whose outcome after contact was evaluated. There were no restrictions on language or related to the date of publication of the articles. Publications were searched and included until 1 November 2022. Articles addressing animal-to-human or human-to-animal contact, vertical transmission, literature reviews, case reports and editorial articles were excluded.”
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched. – MANDATÓRIO <i>Em consonância com as boas práticas da Cochrane, é mandatório que se verifique pesquisa em pelo menos duas bases de pesquisa bibliográfica (idealmente, deverão ser pesquisadas duas bases generalistas e uma específica da área). No caso de revisões sistemáticas de estudos experimentais/ensaios clínicos aleatorizados, é altamente recomendado que uma das bases pesquisadas corresponda à CENTRAL ou a bases de ensaios clínicos como a ClinicalTrials.gov. Estudos de revisão da literatura em que a pesquisa decorra numa única base de dados não serão classificados como revisões sistemáticas.</i>	Página 2 (parágrafo 6): <i>“2.3. Information Sources and Search Strategy</i> A systematic search was carried out in PubMed, Scopus and Web of Science on 1 November 2022.” Página 2 (parágrafo 5): <i>“There were no restrictions on language or related to the date of publication of the articles. Publications were searched and included until 1 November 2022.”</i>
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated. – MANDATÓRIO <i>A query de pesquisa deve ser obrigatoriamente disponibilizada. A utilização de filtros de pesquisa da InterTASC é altamente recomendada</i>	Material suplementar (em anexo) “Monkeypox[Title/Abstract] AND (transmission[Title/Abstract] OR transmissions[Title/Abstract] OR transmissibility[Title/Abstract] OR transmissible[Title/Abstract] OR clothing[Title/Abstract] OR clothes[Title/Abstract] OR contact[Title/Abstract] OR surface[Title/Abstract] OR surfaces[Title/Abstract] OR

		https://sites.google.com/a/york.ac.uk/issg-search-filters-resource/home)	fomite[Title/Abstract] OR fomites[Title/Abstract] OR particle[Title/Abstract] OR particles[Title/Abstract] OR sexual[Title/Abstract] OR mucous[Title/Abstract] OR contaminated[Title/Abstract] OR contamination[Title/Abstract] OR respiratory[Title/Abstract] OR skin[Title/Abstract] OR skin-to-skin[Title/Abstract]) AND (humans[All Fields] OR human[All Fields]) NOT (review[Publication Type]) NOT (editorial[Publication Type]) NOT (case reports[Publication Type])" Página 2 (parágrafo 6): "The queries used are presented in Table 1 (Supplementary File S1) and included the terms "monkeypox", "transmission", "transmissions", "transmissibility", transmissible", "clothing", "clothes", "contact", "surface", "surfaces", "fomite", "fomites", "particle", "particles", "sexual", "mucous", "contaminated", "contamination", "respiratory", "skin", "skin-to-skin", "humans" and "human"."
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis). – MANDATÓRIO <i>As fases de selecção dos estudos primários devem ser descritas. Em consonância com as boas práticas da Cochrane, é mandatório que o processo de selecção envolva duas fases (fase de rastreio, em que os registos são seleccionados por título e abstract, e fase de inclusão, na qual se procede à leitura integral dos full texts). Em cada uma destas fases, o processo de selecção deve mandatoriamente envolver dois investigadores actuando de forma independente.</i>	Página 3 (parágrafo 1): <i>2.4. Study Selection</i> Two independent researchers (P.P. and M.A.C.) selected the articles one by one for inclusion or exclusion based on title and abstract. The conflicts were solved by a third researcher (C.L.). The full text of the resulting articles was analyzed by two researchers, who selected independently the articles for inclusion. Once more, potential conflicts were discussed and solved by a third author."
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators. – MANDATÓRIO <i>Trata-se de descrever de que forma se procedeu à extracção de dados dos estudos primários. Em consonância com as boas práticas da Cochrane, tal processo deverá envolver dois investigadores de forma independente.</i>	Página 3 (parágrafo 3): <i>2.5. Data Collection Process</i> Three authors (P.P., M.A.C. and M.F.M.G.) extracted information independently from the included articles and reached consensus for data inclusion. Data extraction was conducted using Microsoft Word software and predefined tables."
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made. – MANDATÓRIO <i>Trata-se de descrever as variáveis para as quais foi obtida informação.</i>	Página 3 (parágrafo 3): "The following information was collected from each included study: author, year of publication, study design, setting data, case definition, type of contact/mode of transmission, index case(s), contacts (possible), secondary cases, conclusion and limitations."

Risk of bias in individual studies / Risk of bias across studies	12/15	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis. – MANDATÓRIO <i>Em todas as revisões sistemáticas, deverá existir um processo de avaliação da qualidade dos estudos primários. No caso de revisões sistemáticas de estudos experimentais/ensaio clínicos aleatorizados, a aplicação dos critérios de risco de viés (Risk of Bias) da Cochrane é altamente recomendada. No caso de revisões sistemáticas de estudos observacionais, poderão ser seguidos os critérios ROBINS ou os critérios dos National Institutes of Health (https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools).</i>	Página 3 (parágrafo 4): “2.6. Study Quality Assessment The risk of bias was evaluated using the quality assessment tool from the National Institutes of Health, which allowed us to classify the studies into poor, fair or good quality depending on the fulfilment of criteria defined by this tool [9]. This assessment was performed by M.A.C., M.F.M.G., and C.L. Divergences resulting from this process were discussed between the authors.”
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means). – FACULTATIVO. APENAS NECESSÁRIO SE FOR FEITA META-ANÁLISE	Não aplicável, uma vez que esta revisão sistemática não se acompanhou de meta-análise.
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I ²) for each meta-analysis. – FACULTATIVO. APENAS NECESSÁRIO SE FOR FEITA META-ANÁLISE	Não aplicável, uma vez que esta revisão sistemática não se acompanhou de meta-análise.
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified. – FACULTATIVO. APLICÁVEL APENAS SE FOR FEITA META-ANÁLISE	Não aplicável, uma vez que esta revisão sistemática não se acompanhou de meta-análise.
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram. – MANDATÓRIO	Página 3 (parágrafo 5): “3.1. Number of Retrieved Papers A total of 1115 articles were found in our first research on the 3 databases, 417 of which were duplicated. Out of 698 articles, 635 were excluded after analysis of title and abstract and 63 were included for full-text analysis. We further excluded 50 articles considering inclusion and exclusion criteria and a final number of 13 observational studies were included in this systematic review: 4 retrospective cohorts and 9 prospective cohorts. These results are summarized in Figure 1.”

			Página 4 (Figure 1. Flow chart of study selection.)
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations. – MANDATÓRIO	Página 4 (parágrafo 1): <i>“3.2. Study Characteristics</i> This systematic review included 13 studies [10-22] (Table 1): 7 studies were from Af-rica [10-13,15-17], 6 of which from Zaire, now called Democratic Republic of the Congo [10-13, 16], 3 studies from the USA [14,21-22], 1 from Singapore [18], and 2 studies from Europe, respectively from United Kingdom and Spain [19,20]. Ten studies were published before 2022 [10-19] and the remaining 3 were published in 2022 [20-22].” Páginas 5-9 (Table 1. Characteristics of the 13 included studies).
Risk of bias within and across studies	19/22	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12). – MANDATÓRIO	Página 10 (parágrafo 4): <i>“3.5. Risk of bias within and across studies</i> A total of 5 studies were considered to have poor quality [10,11,15,17,20], 6 studies were considered fair [14,16,18,19,21,22] and 2 studies were good [12,13]. The studies with poor quality consequently resulted in low levels of evidence. Participants were lost to follow-up in some studies and others have a very low population size. The same cases were probably present in different included studies, which can result in duplicate information. The usage of gloves and other protective equipment makes somewhat difficult to measure adequately the exposure of contacts. A previous vaccination history could underestimate the risk of transmission to unvaccinated individuals. Outcomes were not always obtained by PCR techniques, having been evaluated only symptomatically, which means that outcome measures were not consistently applied within and across studies. Additionally, the studies are not entirely comparable because they occurred in different places, at different moments in time, and they must be analyzed taking these questions into account.” Página 10 (parágrafo 1-3) – outcome assessment: <i>“3.3. Outcome assessment and evidence of contact with MPXV”</i> <i>“3.4. Evidence of transmission”</i> Páginas 5-9 (Table 1. Characteristics of the 13 included studies).
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot. – FACULTATIVO. APLICÁVEL APENAS SE FOR FEITA META-ANÁLISE	Não aplicável, uma vez que esta revisão sistemática não se acompanhou de meta-análise.
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency. – FACULTATIVO. MANDATÓRIO APENAS SE FOR	Não aplicável, uma vez que esta revisão sistemática não se acompanhou de meta-análise.

		FEITA META-ANÁLISE	
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]). – FACULTATIVO. APLICÁVEL APENAS SE FOR FEITA META-ANÁLISE	Não aplicável, uma vez que esta revisão sistemática não se acompanhou de meta-análise.
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers). – MANDATÓRIO	Página 10 (parágrafo 5) e página 11 (parágrafos 1-6): <i>“Summary of evidence</i> Although several studies suggested a household transmission of the virus, the type of contact occurring in the habitation is difficult to understand [10-13,15,20]... Although it has been shown that individuals were more prone to acquire infection following sexual contact, we need more clear evidence that clearly states that.”
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias). – MANDATÓRIO	Página 12 (parágrafos 1-3): <i>“Limitations</i> This systematic review poses several limitations. Some studies showed low quality or did not mention what type of person-to-person contact played a role in the transmission [10,11,15,17,20]... People might have contacted in different ways at the same time, thus making it difficult to know what type of contact was responsible for infection.”
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research. – MANDATÓRIO	Página 12 (parágrafo 4-6): <i>“Conclusions</i> The recent outbreak of MPXV still is of great concern. Cases of infection have been reported in several countries, worldwide, and the virus transmission initially started to be mainly by person-to-person contact... In future investigation, it is necessary to maintain a good follow-up of case contacts and to establish correctly the type of contact between people. In addition, confirmation of Mpox infection by PCR should be considered in all studies.”
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review. – SEGUIR RECOMENDAÇÕES DA REVISTA	Página 12 (parágrafo 9): “Funding: This research was part of the project NORTE-01-0145-FEDER-000057 (SexHealth & Prostate Cancer, Psychobiological Determinants of Sexual Health in Men with Prostate Cancer), financial support from the Horizon Europe programme and Norte 2020.Institutional Review Board Statement: Not applicable.”

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

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Instructions for Authors

Shortcuts

- Manuscript Submission Overview
- Manuscript Preparation
- Preparing Figures, Schemes and Tables
- Original Images for Blots and Gels Requirements
- Supplementary Materials, Data Deposit and Software Source Code
- Research and Publication Ethics
- Reviewer Suggestions
- English Corrections
- Preprints and Conference Papers
- Authorship
- Editorial Independence
- Conflicts of Interest
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Restrictions on data availability should be noted during submission and in the manuscript. "Data not shown" should be avoided: authors are encouraged to publish all observations related to the submitted manuscript as Supplementary Material. "Unpublished data" intended for publication in a manuscript that is either planned, "in preparation" or "submitted" but not yet accepted, should be cited in the text and a reference should be added in the References section. "Personal Communication" should also be cited in the text and reference added in the References section. (see also the MDPI reference list and citations style guide).

Remote Hosting and Large Data Sets

Data may be deposited with specialized service providers or institutional/subject repositories, preferably those that use the DataCite mechanism. Large data sets and files greater than 60 MB must be deposited in this way. For a list of other repositories specialized in scientific and experimental data, please consult databib.org or re3data.org. The data repository name, link to the data set (URL) and accession number, doi or handle number of the data set must be provided in the paper. The journal Data also accepts submissions of data set papers.

Deposition of Sequences and Expression Data

New sequence information must be deposited to the appropriate database prior to submission of the manuscript. Accession numbers provided by the database should be included in the submitted manuscript. Manuscripts will not be published until the accession number is provided.

- **New nucleic acid sequences** must be deposited into an acceptable repository such as GenBank, EMBL, or DDBJ. Sequences should be submitted to only one database.
- **New high throughput sequencing (HTS) datasets** (RNA-seq, ChIP-Seq, degradome analysis, ...) must be deposited either in the GEO database or in the NCBI's Sequence Read Archive (SRA).

- *New microarray data* must be deposited either in the GEO or the ArrayExpress databases. The "Minimal Information About a Microarray Experiment" (MIAME) guidelines published by the Microarray Gene Expression Data Society must be followed.
- *New protein sequences* obtained by protein sequencing must be submitted to UniProt (submission tool SPIN). Annotated protein structure and its reference sequence must be submitted to RCSB of Protein Data Bank.

All sequence names and the accession numbers provided by the databases must be provided in the Materials and Methods section of the article.

Deposition of Proteomics Data

Methods used to generate the proteomics data should be described in detail and we encourage authors to adhere to the "Minimum Information About a Proteomics Experiment". All generated mass spectrometry raw data must be deposited in the appropriate public database such as ProteomeXchange, PRIDE or jPOST. At the time of submission, please include all relevant information in the materials and methods section, such as repository where the data was submitted and link, data set identifier, username and password needed to access the data.

Research and Publication Ethics

Research Ethics

Research Involving Human Subjects

When reporting on research that involves human subjects, human material, human tissues, or human data, authors must declare that the investigations were carried out following the rules of the Declaration of Helsinki of 1975 (<https://www.wma.net/what-we-do/medical-ethics/declaration-of-helsinki/>), revised in 2013. According to point 23 of this declaration, an approval from the local institutional review board (IRB) or other appropriate ethics committee must be obtained before undertaking the research to confirm the study meets national and international guidelines. As a minimum, a statement including the project identification code, date of approval, and name of the ethics committee or institutional review board must be stated in Section 'Institutional Review Board Statement' of the article.

Example of an ethical statement: "All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of XXX (Project identification code)."

For non-interventional studies (e.g. surveys, questionnaires, social media research), all participants must be fully informed if the anonymity is assured, why the research is being conducted, how their data will be used and if there are any risks associated. As with all research involving humans, ethical approval from an appropriate ethics committee must be obtained prior to conducting the study. If ethical approval is not required, authors must either provide an exemption from the ethics committee or are encouraged to cite the local or national legislation that indicates ethics approval is not required for this type of study. Where a study has been granted exemption, the name of the ethics committee which provided this should be stated in Section 'Institutional Review Board Statement' with a full explanation regarding why ethical approval was not required.

A written informed consent for publication must be obtained from participating patients. Data relating to individual participants must be described in detail, but private information identifying participants need not be included unless the identifiable materials are of relevance to the research (for example, photographs of participants' faces that show a particular symptom). Patients' initials or other personal identifiers must not appear in any images. For manuscripts that include any case details, personal information, and/or images of patients, authors must obtain signed informed consent for publication from patients (or their relatives/guardians) before submitting to an MDPI journal. Patient details must be anonymized as far as possible, e.g., do not mention specific age, ethnicity, or occupation where they are not relevant to the conclusions. A template permission form is available to download. A blank version of the form used to obtain permission (without the patient names or signature) must be uploaded with your submission. Editors reserve the right to reject any submission that does not meet these requirements.

You may refer to our sample form and provide an appropriate form after consulting with your affiliated institution. For the purposes of publishing in MDPI journals, a consent, permission, or release form should include unlimited permission for publication in all formats (including print, electronic, and online), in sublicensed and reprinted versions (including translations and derived works), and in other works and products under open access license. To respect patients' and any other individual's privacy, please do not send signed forms. The journal reserves the right to ask authors to provide signed forms if necessary.

If the study reports research involving vulnerable groups, an additional check may be performed. The submitted manuscript will be scrutinized by the editorial office and upon request, documentary evidence (blank consent forms and any related discussion documents from the ethics board) must be supplied. Additionally, when studies describe groups by race, ethnicity, gender, disability, disease, etc., explanation regarding why such categorization was needed must be clearly stated in the article.

Ethical Guidelines for the Use of Animals in Research

The editors will require that the benefits potentially derived from any research causing harm to animals are significant in relation to any cost endured by animals, and that procedures followed are unlikely to cause offense to the majority of readers. Authors should particularly ensure that their research complies with the commonly-accepted '3Rs [1]':

- Replacement of animals by alternatives wherever possible,
- Reduction in number of animals used, and
- Refinement of experimental conditions and procedures to minimize the harm to animals.

Authors must include details on housing, husbandry and pain management in their manuscript.

For further guidance authors should refer to the Code of Practice for the Housing and Care of Animals Used in Scientific Procedures [2], American Association for Laboratory Animal Science [3] or European Animal Research Association [4].

If national legislation requires it, studies involving vertebrates or higher invertebrates must only be carried out after obtaining approval from the appropriate ethics committee. As a minimum, the project identification code, date of approval and name of the ethics committee or institutional review board should be stated in Section 'Institutional Review Board Statement'. Research procedures must be carried out in accordance with national and institutional regulations. Statements on animal welfare should confirm that the study complied with all relevant legislation. Clinical studies involving animals and interventions outside of routine care require ethics committee oversight as per the American Veterinary Medical Association. If the study involved client-owned animals, informed client consent must be obtained and certified in the manuscript report of the research. Owners must be fully informed if there are any risks associated with the procedures and that the research will be published. If available, a high standard of veterinary care must be provided. Authors are responsible for correctness of the statements provided in the manuscript.

If ethical approval is not required by national laws, authors must provide an exemption from the ethics committee, if one is available. Where a study has been granted exemption, the name of the ethics committee that provided this should be stated in Section 'Institutional Review Board Statement' with a full explanation on why the ethical approval was not required.

If no animal ethics committee is available to review applications, authors should be aware that the ethics of their research will be evaluated by reviewers and editors. Authors should provide a statement justifying the work from an ethical perspective, using the same utilitarian framework that is used by ethics committees. Authors may be asked to provide this even if they have received ethical approval.

MDPI endorses the ARRIVE guidelines (arriveguidelines.org/) for reporting experiments using live animals. Authors and reviewers must use the ARRIVE guidelines as a checklist, which can be found at <https://arriveguidelines.org/sites/arrive/files/documents/ARRIVE%20Compliance%20Questionnaire.pdf>. Editors reserve the right to ask for the checklist and to reject submissions that do not adhere to these guidelines, to reject submissions based on ethical or animal welfare concerns or if the procedure described does not appear to be justified by the value of the work presented.

1. NSW Department of Primary Industries and Animal Research Review Panel. Three Rs. Available online: <https://www.animaethics.org.au/three-rs>

2. Home Office. Animals (Scientific Procedures) Act 1986. Code of Practice for the Housing and Care of Animals Bred, Supplied or Used for Scientific Purposes. Available online: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/388535/CoPanimalsWeb.pdf
3. American Association for Laboratory Animal Science. The Scientific Basis for Regulation of Animal Care and Use. Available online: <https://www.aalas.org/about-aalas/position-papers/scientific-basis-for-regulation-of-animal-care-and-use>
4. European Animal Research Association. EU regulations on animal research. Available online: <https://www.eara.eu/animal-research-law>

Research Involving Cell Lines

Methods sections for submissions reporting on research with cell lines should state the origin of any cell lines. For established cell lines the provenance should be stated and references must also be given to either a published paper or to a commercial source. If previously unpublished *de novo* cell lines were used, including those gifted from another laboratory, details of institutional review board or ethics committee approval must be given, and confirmation of written informed consent must be provided if the line is of human origin.

An example of Ethical Statements:

The HCT116 cell line was obtained from XXXX. The MLH1⁺ cell line was provided by XXXXX, Ltd. The DLD-1 cell line was obtained from Dr. XXXX. The DR-GFP and SA-GFP reporter plasmids were obtained from Dr. XXX and the Rad51K133A expression vector was obtained from Dr. XXXX.

Research Involving Plants

Experimental research on plants (either cultivated or wild) including collection of plant material, must comply with institutional, national, or international guidelines. We recommend that authors comply with the Convention on Biological Diversity and the Convention on the Trade in Endangered Species of Wild Fauna and Flora.

For each submitted manuscript supporting genetic information and origin must be provided. For research manuscripts involving rare and non-model plants (other than, e.g., *Arabidopsis thaliana*, *Nicotiana benthamiana*, *Oryza sativa*, or many other typical model plants), voucher specimens must be deposited in an accessible herbarium or museum. Vouchers may be requested for review by future investigators to verify the identity of the material used in the study (especially if taxonomic rearrangements occur in the future). They should include details of the populations sampled on the site of collection (GPS coordinates), date of collection, and document the part(s) used in the study where appropriate. For rare, threatened or endangered species this can be waived but it is necessary for the author to describe this in the cover letter.

Editors reserve the rights to reject any submission that does not meet these requirements.

An example of Ethical Statements:

Torenia fournieri plants were used in this study. White-flowered Crown White (CrW) and violet-flowered Crown Violet (CrV) cultivars selected from 'Crown Mix' (XXX Company, City, Country) were kindly provided by Dr. XXX (XXX Institute, City, Country).

Arabidopsis mutant lines (SALKxxxx, SAILxxxx,...) were kindly provided by Dr. XXX, institute, city, country).

Clinical Trials Registration

Registration

MDPI follows the International Committee of Medical Journal Editors (ICMJE) guidelines which require and recommend registration of clinical trials in a public trials registry at or before the time of first patient enrollment as a condition of consideration for publication.

Purely observational studies do not require registration. A clinical trial not only refers to studies that take place in a hospital or involve pharmaceuticals, but also refer to all studies which involve participant randomization and group classification in the context of the intervention under assessment.

Authors are strongly encouraged to pre-register clinical trials with an international clinical trials register and cite a reference to the registration in the Methods section. Suitable databases include clinicaltrials.gov, the EU Clinical Trials Register and those listed by the World Health Organisation International Clinical Trials Registry Platform.

Approval to conduct a study from an independent local, regional, or national review body is not equivalent to prospective clinical trial registration. MDPI reserves the right to decline any paper without trial registration for further peer-review. However, if the study protocol has been published before the enrolment, the registration can be waived with correct citation of the published protocol.

CONSORT Statement

MDPI requires a completed CONSORT 2010 checklist and flow diagram as a condition of submission when reporting the results of a randomized trial. Templates for these can be found here or on the CONSORT website (<http://www.consort-statement.org>) which also describes several CONSORT checklist extensions for different designs and types of data beyond two group parallel trials. At minimum, your article should report the content addressed by each item of the checklist.

Sex and Gender in Research

We encourage our authors to follow the 'Sex and Gender Equity in Research – SAGER – guidelines' and to include sex and gender considerations where relevant. Authors should use the terms sex (biological attribute) and gender (shaped by social and cultural circumstances) carefully in order to avoid confusing both terms. Article titles and/or abstracts should indicate clearly what sex(es) the study applies to. Authors should also describe in the background, whether sex and/or gender differences may be expected; report how sex and/or gender were accounted for in the design of the study; provide disaggregated data by sex and/or gender, where appropriate; and discuss respective results. If a sex and/or gender analysis was not conducted, the rationale should be given in the Discussion. We suggest that our authors consult the full guidelines before submission.

Borders and Territories

Potential disputes over borders and territories may have particular relevance for authors in describing their research or in an author or editor correspondence address, and should be respected. Content decisions are an editorial matter and where there is a potential or perceived dispute or complaint, the editorial team will attempt to find a resolution that satisfies parties involved.

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Publication Ethics Statement

Viruses is a member of the Committee on Publication Ethics (COPE). We fully adhere to its Code of Conduct and to its Best Practice Guidelines.

The editors of this journal enforce a rigorous peer-review process together with strict ethical policies and standards to ensure to add high quality scientific works to the field of scholarly publication. Unfortunately, cases of plagiarism, data falsification, image manipulation, inappropriate authorship credit, and the like, do arise. The editors of *Viruses* take such publishing ethics issues very seriously and are trained to proceed in such cases with a zero tolerance policy.

Authors wishing to publish their papers in *Viruses* must abide to the following:

- Any facts that might be perceived as a possible conflict of interest of the author(s) must be disclosed in the paper prior to submission.
- Authors should accurately present their research findings and include an objective discussion of the significance of their findings.
- Data and methods used in the research need to be presented in sufficient detail in the paper, so that other researchers can replicate the work.
- Raw data should preferably be publicly deposited by the authors before submission of their manuscript. Authors need to at least have the raw data readily available for presentation to the referees and the editors

of the journal, if requested. Authors need to ensure appropriate measures are taken so that raw data is retained in full for a reasonable time after publication.

- Simultaneous submission of manuscripts to more than one journal is not tolerated.
- The journal accepts exact translations of previously published work. All submissions of translations must conform with our policies on translations.
- If errors and inaccuracies are found by the authors after publication of their paper, they need to be promptly communicated to the editors of this journal so that appropriate actions can be taken. Please refer to our policy regarding Updating Published Papers.
- Your manuscript should not contain any information that has already been published. If you include already published figures or images, please obtain the necessary permission from the copyright holder to publish under the CC-BY license. For further information, see the Rights and Permissions page.
- Plagiarism, data fabrication and image manipulation are not tolerated.

- Plagiarism is not acceptable in *Viruses* submissions.

Plagiarism includes copying text, ideas, images, or data from another source, even from your own publications, without giving any credit to the original source.

Reuse of text that is copied from another source must be between quotes and the original source must be cited. If a study's design or the manuscript's structure or language has been inspired by previous works, these works must be explicitly cited.

All MDPI submissions are checked for plagiarism using the industry standard software iThenticate. If plagiarism is detected during the peer review process, the manuscript may be rejected. If plagiarism is detected after publication, an investigation will take place and action taken in accordance with our policies.

- Image files must not be manipulated or adjusted in any way that could lead to misinterpretation of the information provided by the original image.

Irregular manipulation includes: 1) introduction, enhancement, moving, or removing features from the original image; 2) grouping of images that should obviously be presented separately (e.g., from different parts of the same gel, or from different gels); or 3) modifying the contrast, brightness or color balance to obscure, eliminate or enhance some information.

If irregular image manipulation is identified and confirmed during the peer review process, we may reject the manuscript. If irregular image manipulation is identified and confirmed after publication, we may correct or retract the paper.

Our in-house editors will investigate any allegations of publication misconduct and may contact the authors' institutions or funders if necessary. If evidence of misconduct is found, appropriate action will be taken to correct or retract the publication. Authors are expected to comply with the best ethical publication practices when publishing with MDPI.

Citation Policy

Authors should ensure that where material is taken from other sources (including their own published writing) the source is clearly cited and that where appropriate permission is obtained.

Authors should not engage in excessive self-citation of their own work.

Authors should not copy references from other publications if they have not read the cited work.

Authors should not preferentially cite their own or their friends', peers', or institution's publications.

Authors should not cite advertisements or advertorial material.

In accordance with COPE guidelines, we expect that "original wording taken directly from publications by other researchers should appear in quotation marks with the appropriate citations." This condition also applies to an author's own work. COPE have produced a discussion document on citation manipulation with recommendations for best practice.

Reviewer Suggestions

During the submission process, five potential reviewers with the appropriate expertise to review the manuscript should be suggested. The editors may or may not use these referees. Detailed contact information (address, homepage, phone, e-mail address) for suggested reviewers should be provided. The proposed referees should neither be current collaborators of the co-authors nor have published with any of the co-authors of the manuscript within the last five years. Proposed reviewers should be from different institutions to the authors. Appropriate Editorial Board members of the journal can be suggested as potential reviewers.

[Return to top]

English Corrections

To facilitate proper peer-reviewing of your manuscript, it is essential that it is submitted in grammatically correct English. Advice on some specific language points can be found [here](#).

MDPI provides minor English editing by native English speakers for all accepted papers, included in the APC. The APC does not cover extensive English editing. Your paper could be returned to you at the English editing stage of the publication process if extensive editing is required. You may choose to use a paid language-editing service, such as MDPI's Author Services, before submitting your paper for publication. If you use an alternative service that provides a confirmation certificate, please send a copy to the Editorial Office. Authors from economically developing countries or nations should consider registration with AuthorAid, a global research community that provides networking, mentoring, resources and training for research.

Preprints and Conference Papers

Viruses accepts submissions that have previously been made available as preprints provided that they have not undergone peer review. A preprint is a draft version of a paper made available online before submission to a journal.

MDPI operates *Preprints*, a preprint server to which submitted papers can be uploaded directly after completing journal submission. Note that *Preprints* operates independently of the journal and posting a preprint does not affect the peer review process. Check the *Preprints* instructions for authors for further information.

Expanded and high-quality conference papers can be considered as articles if they fulfill the following requirements: (1) the paper should be expanded to the size of a research article; (2) the conference paper should be cited and noted on the first page of the paper; (3) if the authors do not hold the copyright of the published conference paper, authors should seek the appropriate permission from the copyright holder; (4) authors are asked to disclose that it is conference paper in their cover letter and include a statement on what has been changed compared to the original conference paper. *Viruses* does not publish pilot studies or studies with inadequate statistical power.

Unpublished conference papers that do not meet the above conditions are recommended to be submitted to the Proceedings Series journals.

Authorship

MDPI follows the International Committee of Medical Journal Editors (ICMJE) guidelines which state that, in order to qualify for authorship of a manuscript, the following criteria should be observed:

- Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND
- Drafting the work or revising it critically for important intellectual content; AND
- Final approval of the version to be published; AND

- Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Those who contributed to the work but do not qualify for authorship should be listed in the acknowledgments. More detailed guidance on authorship is given by the International Council of Medical Journal Editors (ICMJE).

Any change to the author list should be approved by all authors including any who have been removed from the list. The corresponding author should act as a point of contact between the editor and the other authors and should keep co-authors informed and involve them in major decisions about the publication. We reserve the right to request confirmation that all authors meet the authorship conditions.

For more details about authorship please check MDPI ethics website.

Reviewers Recommendation

Authors can recommend potential reviewers. Journal editors will check to make sure there are no conflicts of interest before contacting those reviewers, and will not consider those with competing interests. Reviewers are asked to declare any conflicts of interest. Authors can also enter the names of potential peer reviewers they wish to exclude from consideration in the peer review of their manuscript, during the initial submission progress. The editorial team will respect these requests so long as this does not interfere with the objective and thorough assessment of the submission.

Editorial Independence

Lack of Interference With Editorial Decisions

Editorial independence is of utmost importance and MDPI does not interfere with editorial decisions. All articles published by MDPI are peer reviewed and assessed by our independent editorial boards, and MDPI staff are not involved in decisions to accept manuscripts. When making an editorial decision, we expect the academic editor to make their decision based only upon:

- The suitability of selected reviewers;
- Adequacy of reviewer comments and author response;
- Overall scientific quality of the paper.

In all of our journals, in every aspect of operation, MDPI policies are informed by the mission to make science and research findings open and accessible as widely and rapidly as possible.

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Editorial staff or editors shall not be involved in processing their own academic work. Submissions authored by editorial staff/editors will be assigned to at least two independent outside reviewers. Decisions will be made by other Editorial Board Members who do not have a conflict of interest with the author. Journal staff are not involved in the processing of their own work submitted to any MDPI journals.

Conflicts of Interest

According to The International Committee of Medical Journal Editors, "Authors should avoid entering into agreements with study sponsors, both for-profit and non-profit, that interfere with authors' access to all of the study's data or that interfere with their ability to analyze and interpret the data and to prepare and publish manuscripts independently when and where they choose."

All authors must disclose all relationships or interests that could inappropriately influence or bias their work. Examples of potential conflicts of interest include but are not limited to financial interests (such as membership, employment, consultancies, stocks/shares ownership, honoraria, grants or other funding, paid

expert testimonies and patent-licensing arrangements) and non-financial interests (such as personal or professional relationships, affiliations, personal beliefs).

Authors can disclose potential conflicts of interest via the online submission system during the submission process. Declarations regarding conflicts of interest can also be collected via the MDPI disclosure form. The corresponding author must include a summary statement in the manuscript in a separate section "Conflicts of Interest" placed just before the reference list. The statement should reflect all the collected potential conflicts of interest disclosures in the form.

See below for examples of disclosures:

Conflicts of Interest: Author A has received research grants from Company A. Author B has received a speaker honorarium from Company X and owns stocks in Company Y. Author C has been involved as a consultant and expert witness in Company Z. Author D is the inventor of patent X.

If no conflicts exist, the authors should state:

Conflicts of Interest: The authors declare no conflicts of interest.

Editorial Procedures and Peer-Review

Initial Checks

All submitted manuscripts received by the Editorial Office will be checked by a professional in-house *Managing Editor* to determine whether they are properly prepared and whether they follow the ethical policies of the journal, including those for human and animal experimentation. Manuscripts that do not fit the journal's ethics policy or do not meet the standards of the journal will be rejected before peer-review. Manuscripts that are not properly prepared will be returned to the authors for revision and resubmission. After these checks, the *Managing Editor* will consult the journals' *Editor-in-Chief* or *Associate Editors* to determine whether the manuscript fits the scope of the journal and whether it is scientifically sound. Reject decisions at this stage will be verified by the *Editor-in-Chief*.

Peer-Review

Once a manuscript passes the initial checks, it will be assigned to at least two independent experts for peer-review. A single-blind review is applied, where authors' identities are known to reviewers. Peer review comments are confidential and will only be disclosed with the express agreement of the reviewer.

In the case of regular submissions, in-house assistant editors will invite experts, including recommendations by an academic editor. These experts may also include *Editorial Board Members* and Guest Editors of the journal. Potential reviewers suggested by the authors may also be considered. Reviewers should not have published with any of the co-authors during the past three years and should not currently work or collaborate with any of the institutions of the co-authors of the submitted manuscript.

Optional Open Peer-Review

The journal operates optional open peer-review: *Authors are given the option for all review reports and editorial decisions to be published alongside their manuscript. In addition, reviewers can sign their review, i.e., identify themselves in the published review reports.* Authors can alter their choice for open review at any time before publication, but once the paper has been published changes will only be made at the discretion of the *Publisher* and *Editor-in-Chief*. We encourage authors to take advantage of this opportunity as proof of the rigorous process employed in publishing their research. To guarantee impartial refereeing, the names of referees will be revealed only if the referees agree to do so, and after a paper has been accepted for publication.

Editorial Decision and Revision

All the articles, reviews and communications published in MDPI journals go through the peer-review process and receive at least two reviews. The in-house editor will communicate the decision of the academic editor, which will be one of the following:

- **Accept after Minor Revisions:**

The paper is in principle accepted after revision based on the reviewer's comments. Authors are given five days for minor revisions.

- **Reconsider after Major Revisions:**

The acceptance of the manuscript would depend on the revisions. The author needs to provide a point by point response or provide a rebuttal if some of the reviewer's comments cannot be revised. A maximum of two rounds of major revision per manuscript is normally provided. Authors will be asked to resubmit the revised paper within a suitable time frame, and the revised version will be returned to the reviewer for further comments. If the required revision time is estimated to be longer than 2 months, we will recommend that authors withdraw their manuscript before resubmitting so as to avoid unnecessary time pressure and to ensure that all manuscripts are sufficiently revised.

- **Reject and Encourage Resubmission:**

If additional experiments are needed to support the conclusions, the manuscript will be rejected and the authors will be encouraged to re-submit the paper once further experiments have been conducted.

- **Reject:**

The article has serious flaws, and/or makes no original significant contribution. No offer of resubmission to the journal is provided.

All reviewer comments should be responded to in a point-by-point fashion. Where the authors disagree with a reviewer, they must provide a clear response.

Author Appeals

Authors may appeal a rejection by sending an e-mail to the Editorial Office of the journal. The appeal must provide a detailed justification, including point-by-point responses to the reviewers' and/or Editor's comments using an appeal form. Appeals can only be submitted following a "reject and decline resubmission" decision and should be submitted within three months from the decision date. Failure to meet these criteria will result in the appeal not being considered further. The *Managing Editor* will forward the manuscript and related information (including the identities of the referees) to a designated *Editorial Board Member*. The Academic Editor being consulted will be asked to provide an advisory recommendation on the manuscript and may recommend acceptance, further peer-review, or uphold the original rejection decision. This decision will then be validated by the *Editor-in-Chief*. A reject decision at this stage is final and cannot be reversed.

Production and Publication

Once accepted, the manuscript will undergo professional copy-editing, English editing, proofreading by the authors, final corrections, pagination, and, publication on the www.mdpi.com website.

Promoting Equity, Diversity and Inclusiveness within MDPI Journals

Our Managing Editors encourage the Editors-in-Chief and Associate Editors to appoint diverse expert Editorial Boards. This is also reflective in our multi-national and inclusive workplace. We are proud to create equal opportunities without regard to gender, ethnicity, sexual orientation, age, religion, or socio-economic status. There is no place for discrimination in our workplace and editors of MDPI journals are to uphold these principles in high regard.

Resource Identification Initiative

To improve the reproducibility of scientific research, the Resource Identification Initiative aims to provide unique persistent identifiers for key biological resources, including antibodies, cell lines, model organisms and tools.

We encourage authors to include unique identifiers - RRDs- provided by the Resource Identification Portal in the dedicated section of the manuscript.

To help authors quickly find the correct identifiers for their materials, there is a single website where all resource types can be found and a 'cite this' button next to each resource, that contains a proper citation text that should be included in the methods section of the manuscript.