"Año de la Unidad la Paz y el Desarrollo"

MEMORANDO DE APROBACIÓN DE EXPEDIENTE Nº 0076-2023-OASG-DIGA-UNFV

A : Bach. Manuel Jesús Ortiz Chávez
Jefe de la Unidad de Contrataciones y Servicios Básicos

ASUNTO : **APROBACIÓN DE EXPEDIENTE CONTRATACIÓN INTERNACIONAL N° 012-2023-UNFV PARA EL SERVICIO PUBLICACIÓN EN LA REVISTA VACCINES/SCOPUS INDEX JOURNAL POR EL ARTÍCULO: COMPARATIVE EPIDEMIOLOGICAL ASESSMENT OF MONKEYPOX INFECTIONS ON A GLOBAL AND CONTINENTALSCALE USING LOGISTIC AND GOMPERTZ MATHEMATICAL MODELS - DR. OLEGARIO MARÍN MACHUCA – FOPCA.**

Ref. : Oficio Nº 6011-2023-UCSB-OASG-UNFV

Fecha : 20 de Diciembre del 2023

Mediante documento en referencia, se solicita la Aprobación del Expediente de Contratación del Procedimiento **CONTRATACIÓN INTERNACIONAL N° 012-2023-UNFV PARA EL SERVICIO PUBLICACIÓN EN LA REVISTA VACCINES/SCOPUS INDEX JOURNAL POR EL ARTÍCULO: COMPARATIVE EPIDEMIOLOGICAL ASESSMENT OF MONKEYPOX INFECTIONS ON A GLOBAL AND CONTINENTALSCALE USING LOGISTIC AND GOMPERTZ MATHEMATICAL MODELS - DR. OLEGARIO MARÍN MACHUCA – FOPCA,** solicitado por el **VICERRECTORADO DE INVESTIGACION.**

El monto estimado es de S/16,900.00 (Dieciséis mil novecientos con 00/100 soles), financiado con Recursos Directamente Recaudados.

El expediente está sustentado por:

1.- Requerimiento del Usuario y Especificaciones Técnicas:

Mediante **PROVEIDO N° 1326-2023-VRIN-UNFV,** la **VICERRECTORADO DE INVESTIGACION,** remite las Especificaciones Técnicas, **SERVICIO PUBLICACIÓN EN LA REVISTA VACCINES/SCOPUS INDEX JOURNAL POR EL ARTÍCULO: COMPARATIVE EPIDEMIOLOGICAL ASESSMENT OF MONKEYPOX INFECTIONS ON A GLOBAL AND CONTINENTALSCALE USING LOGISTIC AND GOMPERTZ MATHEMATICAL MODELS - DR. OLEGARIO MARÍN MACHUCA – FOPCA.**

2.- Estudio de Mercado:

Informe de Indagación de Mercado Nº 079-2023-UCSB-OASG-UNFV, **Valor Estimado Actualizado es de S/ 16,900.00 Soles.**

3.- Certificación Presupuestal:

OFICIO Nº 3282-2023-OCPL-UNFV, en el cual adjunta la Certificación Presupuestal por el importe de **S/ 16,900.00** soles

…///

///...Continua MEMORANDO **DE APROBACIÓN DE EXPEDIENTE Nº 0076-2023-OASG-DIGA-UNFV**

Por lo indicado, de conformidad con el D.L. Nº 30225, Ley de Contrataciones del Estado y el D.S. Nº 0344-2018-EF, Reglamento de la Ley de Contrataciones del Estado; asimismo, la Resolución Rectoral Nº 2724-2018-UNFV que aprueba la Directiva que norma la Organización Interna y Desarrollo de los Procesos de Adquisiciones y Contrataciones del Estado en la Universidad Nacional Federico Villarreal, que en el numeral 4.1 delega la facultad de aprobar los expedientes de Contratación a la Jefatura de la Oficina de Abastecimiento y Servicios Generales; se Aprueba el Expediente de Contratación del Procedimiento de Selección: **CONTRATACIÓN INTERNACIONAL N° 012-2023-UNFV PARA EL SERVICIO PUBLICACIÓN EN LA REVISTA VACCINES/SCOPUS INDEX JOURNAL POR EL ARTÍCULO: COMPARATIVE EPIDEMIOLOGICAL ASESSMENT OF MONKEYPOX INFECTIONS ON A GLOBAL AND CONTINENTALSCALE USING LOGISTIC AND GOMPERTZ MATHEMATICAL MODELS - DR. OLEGARIO MARÍN MACHUCA – FOPCA**; con el valor estimado de **S/ 16,900.00 soles**.

Atentamente,

UNIVERSIDAD NACIONAL FEDERICO VILLARREAL
OFICINA DE ABASTECIMIENTO Y SERVICIOS GENERALES
LIMA - PERU

Lic. JULIO GREGORIO TALLA RAMOS
JEFE
OFICINA DE ABASTECIMIENTO Y SERVICIOS GENERALES

NT: 80588
JGTR/jmpm

FORMATO N° 10
APROBACIÓN DE EXPEDIENTE DE CONTRATACIÓN

1	**DATOS DE LA APROBACIÓN**	Número	**N° 076-2023-OASG-DIGA-UNFV**
		Fecha	**20 de diciembre de 2023**

2	**BASE LEGAL**
	Numeral 42.1 del Artículo 42° del Reglamento de la Ley de Contrataciones del Estado: "El órgano encargado de las contrataciones lleva un expediente del proceso de contratación, en el que se ordena, archiva y preserva la información que respalda las actuaciones realizadas desde la formulación del requerimiento del área usuaria hasta el cumplimiento total de las obligaciones derivadas del contrato (…).; Numeral 42.3 del Artículo 42 del Reglamento de la Ley de Contrataciones del Estado: "(...) Para su aprobación, el expediente de contratación contiene: a) El requerimiento, indicando si este se encuentra definido en una ficha de homologación, en el listado de bienes y servicios comunes, o en el Catálogo Electrónico de Acuerdo Marco; b) La fórmula de reajuste, de ser el caso; c) La declaratoria de viabilidad en el caso contrataciones que forman parte de un proyecto de inversión o la aprobación de las inversiones de optimización, ampliación marginal, reposición y rehabilitación reguladas en la normativa aplicable; d) En el caso de obras contratadas bajo la modalidad llave en mano que cuenten con equipamiento, las especificaciones técnicas de los equipos requeridos; e) En el caso de ejecución de obras, el sustento de que procede efectuar la entrega parcial del terreno, de ser el caso; f) El informe técnico de evaluación de software, conforme a la normativa de la materia, cuando corresponda; g) El documento que aprueba el proceso de estandarización, cuando corresponda; h) La indagación de mercado realizada, y su actualización cuando corresponda; i) El valor referencial o valor estimado, según corresponda, j) La opción de realizar la contratación por paquete, lote y tramo, cuando corresponda; k) La certificación de crédito presupuestario y/o la previsión presupuestal, de acuerdo a la normativa vigente; l) La determinación del procedimiento de selección, el sistema de contratación y, cuando corresponda, la modalidad de contratación con el sustento correspondiente; m) El resumen ejecutivo, cuando corresponda; y, n) Otra documentación necesaria conforme a la normativa que regula el objeto de la contratación.

3	**OBSERVACIONES**
	Ref. Oficio N°6011-2023-UCSB-OASG-UNFV - Aprobación de Expediente CONTRATACIÓN INTERNACIONAL N° 012-2023-UNFV para el SERVICIO PUBLICACIÓN EN LA REVISTA VACCINES/SCOPUS INDEX JOURNAL POR EL ARTÍCULO: COMPARATIVE EPIDEMIOLOGICAL ASESSMENT OF MONKEYPOX INFECTIONS ON A GLOBAL AND CONTINENTALSCALE USING LOGISTIC AND GOMPERTZ MATHEMATICAL MODELS - DR. OLEGARIO MARÍN MACHUCA - FOPCA.

4	**DECISIÓN QUE SE ADOPTA**
	Teniendo a la vista el expediente de contratación, por el presente documento el funcionario que suscribe aprueba dicho expediente, considerando que la información consignada en la solicitud se ajusta a las disposiciones de la Ley de Contrataciones del Estado, su T.U.O., su Reglamento y modificatorias.

5

UNIVERSIDAD NACIONAL FEDERICO VILLARREAL
OFICINA DE ABASTECIMIENTO Y SERVICIOS GENERALES
LIMA - PERU

LIC. JULIO GREGORIO TALLA RAMOS
Jefe
Oficina de Abastecimiento y
Servicios Generales

	NOMBRE, FIRMA Y SELLO DEL FUNCIONARIO QUE APRUEBA EL EXPEDIENTE DE CONTRATACIÓN

"Año de la unión, la paz y el desarrollo"

Pueblo Libre, 19 de diciembre de 2023

OFICIO Nº 6011–2023–UCSB–OASG–UNFV

Señor Lic
JULIO GREGORIO TALLA RAMOS
Jefe de la Oficina Abastecimiento y Servicios Generales
Presente. -

Asunto: *Aprobación de Expediente CONTRATACIÓN INTERNACIONAL N° 012-2023-UNFV para el SERVICIO PUBLICACIÓN EN LA REVISTA VACCINES/SCOPUS INDEX JOURNAL POR EL ARTÍCULO: COMPARATIVE EPIDEMIOLOGICAL ASESSMENT OF MONKEYPOX INFECTIONS ON A GLOBAL AND CONTINENTALSCALE USING LOGISTIC AND GOMPERTZ MATHEMATICAL MODELS - DR. OLEGARIO MARÍN MACHUCA - FOPCA.*

Referencia: *Proveído N° 1326-2023-VRIN-UNFV*

Es grato dirigirme a usted para saludarlo muy cordialmente y a la vez remitir para su aprobación el expediente de contratación para el servicio materia del asunto, para el presente procedimiento de selección se cuenta con la siguiente información:

Objeto de la Convocatoria	***Contratación Internacional***
Valor Estimado	***S/16,900.00 (Dieciséis mil novecientos con 00/100 soles)***
Certificación Presupuestal	***OFICIO N°3282-2023-OCPL-UNFV***
Tipo de procedimiento de selección	***Contratación Internacional***
Modalidad de Selección	_
Sistema de Contratación	***Suma Alzada***
Finalidad publica según usuario (s)	***El instituto Central de Gestión de la Investigación tiene como parte de sus funciones promover la investigación, producción científica, innovación y emprendimiento de los docentes y estudiantes de la Universidad Nacional Federico Villarreal, estableciendo estrategias que coadyuven a cumplir con las metas propuestas.***

Atentamente,

UNIVERSIDAD NACIONAL FEDERICO VILLARREAL – UNIDAD DE CONTRATACIONES Y SERVICIOS BASICOS – OFICINA DE ABASTECIMIENTO Y SERVICIOS GENERALES

Bach. MANUEL ORTIZ CHAVEZ
Jefe Unidad de Contrataciones y Servicios Básicos

MOCH//nbch

"Año de la unión, la paz y el desarrollo"

NT: 80588-2023

INFORMACIÓN SOBRE EL PROCEDIMIENTO DE SELECCIÓN

Descripción: *SERVICIO PUBLICACIÓN EN LA REVISTA VACCINES/SCOPUS INDEX JOURNAL POR EL ARTÍCULO: COMPARATIVE EPIDEMIOLOGICAL ASESSMENT OF MONKEYPOX INFECTIONS ON A GLOBAL AND CONTINENTALSCALE USING LOGISTIC AND GOMPERTZ MATHEMATICAL MODELS - DR. OLEGARIO MARÍN MACHUCA - FOPCA*	***Denominación:*** *Contratación Internacional N° 012-2023-UNFV*
S/16,900.00 (Dieciséis mil novecientos con 00/100 soles)	*Indagación de Mercado:* *Resumen Ejecutivo N° 079-2023-UCSB-OCSA-UNFV*

RESPALDO PRESUPUESTAL

PROCEDIMIENTO PROGRAMADO:	***SI( ) NO(x)***
Monto Estimado: ***S/16,900.00 (Dieciséis mil novecientos con 00/100 soles***	***Documentación que autoriza:*** _
Fuente de Financiamiento: *Recursos Directamente Recaudados*	
Observaciones: ----	***Certificación Presupuestal:*** ***OFICIO N°3282-2023-OCPL-UNFV*** *Certificado N° 1982*

Atentamente,

UNIVERSIDAD NACIONAL FEDERICO VILLARREAL
UNIDAD DE CONTRATACIONES Y SERVICIOS BASICOS
OFICINA DE ABASTECIMIENTO Y SERVICIOS GENERALES

Bach. MANUEL JESUS ORTIZ CHÁVEZ
Jefe
Unidad de Contrataciones y Servicios Básicos

FORMATO Nº 08
FORMATO PARA SOLICITAR APROBACIÓN DEL EXPEDIENTE DE CONTRATACIÓN

SOLICITUD DE APROBACIÓN DEL EXPEDIENTE DE CONTRATACIÓN

(PARA SER LLENADO POR EL ÓRGANO ENCARGADO DE LAS CONTRATACIONES DE LA ENTIDAD)

1	**NÚMERO Y FECHA DEL DOCUMENTO**	Número	OFICIO N° 6011–2023–UCSB–OASG–UNFV
		Fecha	19/12/2023

2	**DEPENDENCIA QUE APROBARÁ EL EXPEDIENTE**
	Oficina de Abastecimiento y Servicios Generales

3	**OBJETO DE LA SOLICITUD**
	Por medio de la presente, el órgano encargado de las contrataciones de la Entidad, solicita la aprobación del expediente contratación del procedimiento que se detalla en el presente documento.

4	**DATOS DEL REQUERIMIENTO**		
	4.1 DEPENDENCIA USUARIA		VICERRECTORADO DE INVESTIGACIÓN
	4.2 REQUERIMIENTO	Número	Proveído N° 1326-2023-VRIN-UNFV
		Fecha	5/12/2023

5	**VINCULACIÓN DEL REQUERIMIENTO CON EL POI Y EL PAC**		
	5.1 POI	Actividad del POI	–
	5.2 PAC	N° de referencia del PAC	NO APLICA

6	**PROYECTO DE INVERSIÓN PÚBLICA**	Código del proyecto	–
		Fecha del formato de Declaratoria de Viabilidad	–
		Fecha del formato de Verificación de Viabilidad	–

7	**DATOS DEL VALOR REFERENCIAL**			
	7.1 VALOR REFERENCIAL	Número del informe	Cuadro Comparativo N° 079-2023-UCSB-OASG-UNFV	
		Fecha de emisión del informe	12 DE DICIEMBRE 2023	
		Monto del valor referencial	S/16,900.00 (Dieciséis mil novecientos con 00/100 soles)	
		Se actualizó el valor referencial	SI	
			NO	X
	7.2 ANTIGÜEDAD DEL VALOR REFERENCIAL	1 mes		

8	**DATOS DE LA CERTIFICACIÓN DE CRÉDITO PRESUPUESTARIO (CCP) Y/O PREVISIÓN PRESUPUESTAL**		
	8.1 CERTIFICACIÓN DE CRÉDITO PRESUPUESTARIO (CCP) Y/O PREVISIÓN PRESUPUESTAL	Número de la CCP	1982
		Fecha de la CCP	14 DE DICIEMBREDE 2023
		Número del documento de Previsión Presupuestal	–
		Fecha del documento	–
		Fuente(s) de Financiamiento	RECURSOS DIRECTAMENTE RECAUDADOS
	8.2 DEVENGADO DE LAS OBLIGACIONES CONTRACTUALES:		
		Las obligaciones contractuales devengarán totalmente en el presente ejercicio fiscal	X
		Las obligaciones contractuales devengarán totalmente en posteriores ejercicios fiscales	

FORMATO Nº 08
FORMATO PARA SOLICITAR APROBACIÓN DEL EXPEDIENTE DE CONTRATACIÓN

		Las obligaciones contractuales devengarán parte en el presente ejercicio fiscal y parte en el(los) próximo(s) ejercicio(s) fiscal(es)	

FORMATO Nº 08
FORMATO PARA SOLICITAR APROBACIÓN DEL EXPEDIENTE DE CONTRATACIÓN

9 DATOS DEL PROCEDIMIENTO DE SELECCIÓN

9.1 DENOMINACIÓN DE LA CONVOCATORIA	SERVICIO PUBLICACIÓN EN LA REVISTA VACCINES/SCOPUS INDEX JOURNAL POR EL ARTÍCULO: COMPARATIVE EPIDEMIOLOGICAL ASESSMENT OF MONKEYPOX INFECTIONS ON A GLOBAL AND CONTINENTALSCALE USING LOGISTIC AND GOMPERTZ MATHEMATICAL MODELS - DR. OLEGARIO MARÍN MACHUCA - FOPCA

9.2 TIPO DE PROCEDIMIENTO DE SELECCIÓN:

Licitación Pública		Adjudicación Simplificada		Subasta Inversa Electrónica	
Concurso Público		Selección de Consultores Individuales		Comparación de Precios	
Contratación Internacional	X				

EN CASO CORRESPONDA A UNA CONTRATACIÓN DIRECTA, DEBE INDICARSE EL SUPUESTO SEGÚN LO PREVISTO EN EL ARTÍCULO 27 DE LA LEY:

Contratación Directa		Supuesto	

9.3 LA CONTRATACIÓN INCLUYE:

Item(s)	X	Paquete(s)	

9.4 SISTEMA DE CONTRATACIÓN:

A Suma Alzada	X	A Precios Unitarios	
Esquema Mixto de Suma Alzada y Precios Unitarios		Tarifas	
En base a Porcentajes		En base a un Honorario Fijo y una Comisión de Éxito	

9.5 MODALIDAD DE EJECUCIÓN:

Llave en mano	SI	
	NO	X
Concurso oferta	SI	
	NO	X
	N° Res	

9.6 FÓRMULA DE REAJUSTE

SI	
NO	X

10 BASE LEGAL

Numeral 42.1 del Artículo 42° del Reglamento de la Ley de Contrataciones del Estado: “El órgano encargado de las contrataciones lleva un expediente del proceso de contratación, en el que se ordena, archiva y preserva la información que respalda las actuaciones realizadas desde la formulación del requerimiento del área usuaria hasta el cumplimiento total de las obligaciones derivadas del contrato (…).

11 OBSERVACIONES

Dada la naturaleza de la prestación, se realizará una Contratación Internacional, considerandose la única cotización válida recibida que cumple con los Términos de Referencia, la misma que ha sido validada por el área usuaria de forma previa

12 SOLICITUD

Por el presente, se solicita la aprobación del expediente de contratación de la Contratación Internacional N° 012-2023-UNFV-1, mencionado en el presente documento

13

UNIDAD DE CONTRATACIONES Y SERVICIOS BASICOS

NOMBRE, FIRMA Y SELLO DEL FUNCIONARIO COMPETENTE DEL ÓRGANO ENCARGADO DE LAS CONTRATACIONES

FORMATO N° 07

INFORME DE INDAGACIÓN EN EL MERCADO N° 0079-2023-UCSB-OASG-UNFV

1	**ÁREA USUARIA**
	VICERRECTORADO DE INVESTIGACION

	DOCUMENTO CON EL QUE SE REMITE EL REQUERIMIENTO	**FECHA**	**N° PEDIDO SIGA**
	PROVEIDO N° 1326-2023-VRIN-UNFV	05.12.2023	2844

3	**FUENTE DE FINANCIAMIENTO**	**MONTO PRESUPUESTADO (S/)**
	RDR	S/ 16,900.00

4	**RELACIÓN DE PROVEEDORES DEL RUBRO INVITADOS Y COTIZACIONES OBTENIDAS**			
	NOMBRE O RAZON SOCIAL		**OBTENCIÓN DE COTIZACIÓN (SI /NO)**	**FECHA DE OBTENCIÓN**
	a)	VACCINES	SI	22/11/2023

5	**DETERMINACIÓN DEL PROVEEDOR SELECCIONADO Y JUSTIFICACIÓN**
	Para el requerimiento se considera la única cotización validada por el área usuaria, adicionando el costo promedio del impuesto aplicable, porcentaje de retención y otros gastos que afectan al costo final de la contratación, en cumplimiento con los Términos de Referencia.
	La presente contratación de acuerdo a la documentación remitida por el área usuaria, se está realizando con un proveedor no domiciliado en el país, en concordancia con las consideraciones establecidas en el literal f) del numeral 5.1 del artículo 5 del T.U.O. de la Ley de Contrataciones del Estado, como supuesto excluido del ámbito de aplicación de la Ley, pero sujetos a supervisión por el Organismo Supervisor de las Contrataciones del Estado (OSCE), y deberá tramitarse de acuerdo a lo establecido en la Directiva "Lineamientos y procedimientos para el acceso al financiamiento del servicio de las publicaciones en revistas indizadas", aprobada mediante Resolución R. N° 236-2022- UNFV.
	Al haberse verificado que se realizará una Contratación Internacional, se deberán aplicar las normas tributarias y tratados internacionales correspondientes y vigentes a la fecha de la presentación del expediente de contratación.
	Sin perjuicio de aplicación de los principios generales de derecho público, para la contratación de servicios del exterior, rigen los principios establecidos en la Ley de Contrataciones del Estado en lo que sea aplicable.

6	**VALOR DE LA CONTRATACIÓN (S/)** **(Incluye impuestos y todo tipo de costos)**
	S/ 16,900.00 soles

7	**JUSTIFICACIÓN DE CANTIDAD MENOR DE COTIZACIONES (marcar solo si aplica)**
	Al haberse verificado que se realizará una Contratación Internacional, dada la naturaleza de la prestación, se considerará la única cotización válida recibida que cumple con los Términos de Referencia, la misma que ha sido validada por el área usuaria de forma previa.

FECHA DE ELABORACIÓN DEL INFORME	12 de diciembre de 2023
NELSON BONIFACIO CHAVEZ	

UNIVERSIDAD NACIONAL FEDERICO VILLARREAL
UNIDAD DE CONTRATACIONES Y SERVICIOS BASICOS
OFICINA DE ABASTECIMIENTO Y SERVICIOS GENERALES

º Bº Manuel Jesús Chávez Ortiz
Jefe de la Unidad de Contrataciones y Servicios Básicos

CUADRO COMPARATIVO Nº 0079-2023-UCSB-OASG-UNFV

SERVICIO PUBLICACIÓN EN LA REVISTA VACCINES/SCOPUS INDEX JOURNAL POR EL ARTÍCULO: COMPARATIVE EPIDEMIOLOGICAL ASESSMENT OF MONKEYPOX INFECTIONS ON A GLOBAL AND CONTINENTALSCALE USING LOGISTIC AND GOMPERTZ MATHEMATICAL MODELS - DR. OLEGARIO MARÍN MACHUCA - FOPCA

ITEM Nº	DESCRIPCIÓN	UNIDAD DE MEDIDA	CANTIDAD	COTIZACIONES RECIBIDAD		FUENTE: PRECIOS DEL SEACE		VALOR ESTIMADO (V.E.)			
				VACCINES		ENTIDAD CONVOCANTE:	UNIVERSIDAD NACIONAL FEDERICO VILLARREAL	PROCEDIMIENTO Y/O METODOLOGÍA UTILIZADO PARA DETERMINAR EL V.E.	VALOR ESTIMADO DEL ITEM	TIPO DE CAMBIO (07.09.2023)	VALOR ESTIMADO DEL ITEM EN MONEDA NACIONAL INCLUYENDO EL 18% DE IGV. EL 30% DE RENTA Y LOS GASTOS OPERATIVOS Y COMISIONES. Según formato N° 03
				RUC:	PROVEEDOR EXTRANJERO	TIPO Y Nº PROCESO DE SELECCIÓN:	INTER-PROC-6-2023-UNFV-1				
				CONTACTO:	MS. HELMI QI	FECHA DE CONSENTIMIENTO DE LA BUENA PRO:	28/08/2023				
				TELÉFONO:	41 61 683 77 34	NOMBRE O RAZÓN SOCIAL DEL ADJUDICATARIO:	RESEARCH GLOBAL PUBLIC HEALTH				
				E-MAIL:	billing@mdpi.com						
				PRECIO UNITARIO (Consignar moneda del valor estimado)	PRECIO TOTAL (Consignar moneda del valor estimado)	PRECIO UNITARIO	PRECIO TOTAL ADJUDICADO				
1	SERVICIO PUBLICACIÓN EN LA REVISTA VACCINES/SCOPUS INDEX JOURNAL POR EL ARTÍCULO: COMPARATIVE EPIDEMIOLOGICAL ASESSMENT OF MONKEYPOX INFECTIONS ON A GLOBAL AND CONTINENTALSCALE USING LOGISTIC AND GOMPERTZ MATHEMATICAL MODELS - DR. OLEGARIO MARÍN MACHUCA - FOPCA	SERVICIO	1.00	2430	2430	4,000.00	4,000.00	Se considera la unica cotización validada por el Funcionario responsable del area usuaria, adicionando el costo promedio del impuesto aplicable, porcentaje de retencion y otros gastos que afecten el costo final de la contratación en cumplimiento a los terminos de referencia.	2430	4.665	S/16,900.00

INFORMACIÓN ADICIONAL DE LA FUENTE	PLAZO DE ENTREGA	SEGÚN TDR	NO APLICA
	GARANTÍA	SEGÚN TDR	NO APLICA
	FORMA DE PAGO	SEGÚN TDR	NO APLICA
	MONEDA DE LA FUENTE	FRANCOS SUIZOS	NO APLICA
	PRECIO UNITARIO EN LA MONEDA CONSIGNADA EN LA FUENTE	2430	NO APLICA
	TIPO DE CAMBIO QUE SE USA	4.665	NO APLICA
ACCIONES ADMINISTRATIVAS REALIZADAS	FECHA DE SOLICITUD	22/11/2023	NO APLICA
	CANTIDAD DE VECES QUE SE REITERO LA SOLICITUD	1	NO APLICA
	FECHA DE RECEPCIÓN	22/11/2023	NO APLICA
	PROVEEDOR SE DEDICA AL OBJETO DE LA CONTRATACIÓN	Si	NO APLICA
	LA DEPENDENCIA USUARIA PARTICIPÓ EN LA VERIFICACIÓN DEL CUMPLIMIENTO DE LOS TDR	SI, SEGÚN VALIDACIÓN REALIZADA POR LA OFICINA DE PROYECTOS DE INVESTIGACIÓN Y LA DIRECCIÓN DEL INSTITUTO CENTRAL DE GESTION DE LA INVESTIGACIÓN. Formato N° 2	NO APLICA
	CUMPLE CON LOS TDR O LA CONTRATACIÓN ES IGUAL O SIMILAR AL REQUERIMIENTO	SI, SEGÚN VALIDACIÓN REALIZADA POR LA OFICINA DE PROYECTOS DE INVESTIGACIÓN Y LA DIRECCIÓN DEL INSTITUTO CENTRAL DE GESTION DE LA INVESTIGACIÓN. Formato N° 2	NO APLICA
	SE TOMO EN CUENTA PARA LA DETERMINACIÓN DEL VALOR ESTIMADO	Si	NO

Cuadro elaborado por: NELSON BONIFACIO CHAVEZ
Unidad de Contrataciones y Servicios Basicos

Vº Bº Manuel Ortiz Chavez
Jefe Unidad de Contrataciones y Servicios Basicos

FECHA DE ELABORACION: 12 de diciembre de 2023

Ficha de Seleccion

Regresar

Convocatoria

Información General

Nomenclatura:	INTER-PROC-6-2023-UNFV-1
N° Convocatoria:	1
Tipo Compra o Selección:	Por la Entidad
Normativa Aplicable:	No Aplica la Normativa Peruana
Versión SEACE	3
Identificador Convocatoria:	935185

Información general de la Entidad

Entidad Convocante:	UNIVERSIDAD NACIONAL FEDERICO VILLARREAL
Direccion Legal:	CALLE CARLOS GONZALES LIMA (LIMA-LIMA-LIMA)
Pagina Web:	
Télefono de la Entidad:	

Información general del procedimiento

Objeto de Contratación:	Servicio
Descripción del Objeto:	SERVICIO DE PUBLICACIÓN DE ARTÍCULO CIENTÍFI...
Valor Estimado / Valor Referencial	4,000.00 Soles
Monto del Derecho de Participacion:	GRATUITO
Fecha y Hora Publicación:	28/08/2023 12:48

Cronograma

Etapa	Fecha Inicio	Fecha Fin
Convocatoria	28/08/2023	28/08/2023
Registro de participantes(Presencial) **OFICINA DE ABASTECIMIENTO Y SERVICIOS GENERALES (CALLE SAN MARCOS N° 351 - PUEBLO LIBRE)**	28/08/2023 10:55	28/08/2023 12:55
Presentación de propuestas(Presencial) **OFICINA DE ABASTECIMIENTO Y SERVICIOS GENERALES (CALLE SAN MARCOS N° 351 - PUEBLO LIBRE)**	28/08/2023 10:55	28/08/2023
Calificación y Evaluación de propuestas **OFICINA DE ABASTECIMIENTO Y SERVICIOS GENERALES (CALLE SAN MARCOS N° 351 - PUEBLO LIBRE)**	28/08/2023	28/08/2023
Otorgamiento de la Buena Pro **OFICINA DE ABASTECIMIENTO Y SERVICIOS GENERALES (CALLE SAN MARCOS N° 351 - PUEBLO LIBRE)**	28/08/2023 12:56	28/08/2023

Ver documentos por Etapa

Lista de Documentos

Nro.	Etapa	Documento	Archivo	Fecha y Hora de publicación	Acciones
1	Convocatoria	Resumen ejecutivo	PDF (139 KB)	28/08/2023 12:48	
2	Convocatoria	Bases Administrativas	PDF (2050 KB)	28/08/2023 12:48	
3	Presentación de propuestas	Documentos de Presentación de Propuestas	ZIP (20 KB)	28/08/2023 13:09	
4	Otorgamiento de la Buena Pro	Documentos de Otorgamiento de Buena Pro	ZIP (1934 KB)	28/08/2023 13:09	

1 de 1 1 5

Ver listado de item

1 - SERVICIO DE PUBLICACIÓN DE ARTÍCULO CIENTÍFICO EN REVISTA INDIZADA INTERNACIONAL - TÍTULO: CEREBROSPINAL FLUID CYTOCHEMICAL ANALYSIS FROM COVID-19 PATIENTS WITH NEUROLOGICAL DISORDERS

Codigo CUBSO: 8212150600385520 **Cantidad:** 1 - Servicio **Reserva Para MYPE:** NO **Paquete:** NO
Denominación del Bien o Servicio Común **Valor Referencial/Estimado Total** 4000 Soles **Estado:** Contratado

Acciones

Postor	MYPE	Ley de promoción de la Selva	Bonificación colindante (Contratación fuera de provincia de Lima y Callao)	Cantidad adjudicada	Monto adjudicado
L0609015606 - RESEARCH GLOBAL PUBLIC HEALTH	NO	NO	NO	1.00	4,000.00

(1 of 1) 1 10

Opciones del procedimiento

Ver documentos del procedimiento	Ver listado de item	Ver acciones generales al procedimiento	Ver contratos	Ver oficios de supervisión	Ver historial de contrataciones	Ver listado de acciones de supervisión	Ver Notificaciones de Supervisión	Ver integrantes y encargado
Visualizar listado de participantes								

Regresar

VICERRECTORADO DE INVESTIGACIÓN

"Año de la unidad, la paz y el desarrollo"

PROVEIDO N° 1326-2023-VRIN-UNFV

RECURRENTE	:	LIC. JULIO GREGORIO TALLA RAMOS OFICINA DE ABASTECIMIENTO Y SERVICIOS GENERALES
REFERENCIA	:	OFICIO N° 5579-2023-UCSB-OASG-UNFV
NT.	:	080469
ASUNTO	:	DEVOLUCIÓN DE EXPEDIENTE PARA ACLARACIÓN DE DATOS DEL PROVEEDOR
FECHA	:	SAN MIGUEL, 05 DE DICIEMBRE DE 2023

PASE A	:	LIC. JULIO GREGORIO TALLA RAMOS OFICINA DE ABASTECIMIENTO Y SERVICIOS GENERALES
PARA	:	SE REMITE EL EXPEDIENTE ACTUALIZADO A TRAVÉS DEL OFICIO N° 724-2023-OPI-ICGI-VRIN-UNFV.

ATENTAMENTE,

UNIVERSIDAD NACIONAL FEDERICO VILLARREAL
REPÚBLICA DEL PERÚ
VICERRECTOR DE INVESTIGACIÓN
LIMA - PERÚ

DR. PEDRO MANUEL AMAYA PINGO
VICERRECTOR DE INVESTIGACIÓN

PMAP/bjlp
C. C.: Archivo

PRIORIDAD: NORMAL
FOLIO: 39

"Año de la unidad, la paz y el desarrollo"

Lima Cercado, 22 de noviembre 2023

OFICIO N° 724-2023-OPI-ICGI-VRIN-UNFV

Señor Doctor
PEDRO M. AMAYA PINGO
Vicerrector de Investigación
Presente.

Asunto: Solicito financiamiento para publicación de artículo DR: OLEGARIO MARIN MACHUCA.

Referencia: PROVEIDO Nº 1085-2023-ICGI-VRIN-UNFV
PROVEIDO N° 1262-2023-VRIN-UNFV

NT. 080469

Tengo el agrado de dirigirme a su Despacho para saludarlo cordialmente e informar respecto a la solicitud que presenta el Dr: OLEGARIO MARIN MACHUCA, docente permanente de la Facultad de Oceanografía, Pesquería, Ciencias Alimentarias y Acuicultura (FOPCA); para que a mérito a la Resolución R. N° 236-2022-UNFV que aprueba la Directiva Lineamientos y Procedimientos para el acceso al financiamiento del servicio de publicaciones en revistas indizadas, se autorice el financiamiento del artículo "Comparative Epidemiological Assessment of Monkeypox In- 2 fections on a Global and Continental Scale Using Logistic and 3 Gompertz Mathematical Models ", aceptado para su publicación; toda vez que cumple con los requisitos:

2.1.1 Filiación Universidad Nacional Federico Villarreal

2.1.2 a) Solicitud firmada por el autor o coautor de la UNFV

b) Es docente ordinario Principal TC.

c) Es coautor del artículo "Comparative Epidemiological Assessment of Monkeypox In- 2 fections on a Global and Continental Scale Using Logistic and 3 Gompertz Mathematical Models ".

d) Adjunta copia del manuscrito a publicar

Asimismo, se adjunta los siguientes formatos:

- Validación de los términos de referencia
- Conversión de moneda y cálculo de obligaciones tributarias
- Autorización para realizar el pago previo a la publicación por derecho a la revista indexada
- Ficha técnica de la revista
- Formato SIGA 002844, por el monto de S/ 16,900.00 soles.

Asimismo, debemos manifestar que mediante el portal web Scimago Journal & Country Rank se ha verificado que a la fecha la revista se encuentra registrada en Scopus, la misma que permite que el articulo a publicar cumpla con lo establecido en la directiva "Lineamientos y procedimientos para el acceso al financiamiento del servicio de las publicaciones en revistas indizasadas".

Se adjunta link para consulta y verificación de la misma.

https://www.scimagojr.com/journalsearch.php?q=21100335701&tip=sid&clean=0

Por lo manifestado, se solicita su aprobación correspondiente a fin de continuar el trámite hasta su atención.

Sin otro particular, hacemos propicia la ocasión para reiterarle nuestra especial consideración.

Atentamente,

UNIVERSIDAD NACIONAL FEDERICO VILLARREAL
OFICINA DE PROYECTOS DE INVESTIGACIÓN
INSTITUTO CENTRAL DE GESTIÓN DE LA INVESTIGACIÓN

Dra. Graciela Martina Monroy Correa
Jefa(e) Oficina de Proyectos de Investigación

UNIVERSIDAD NACIONAL FEDERICO VILLARREAL
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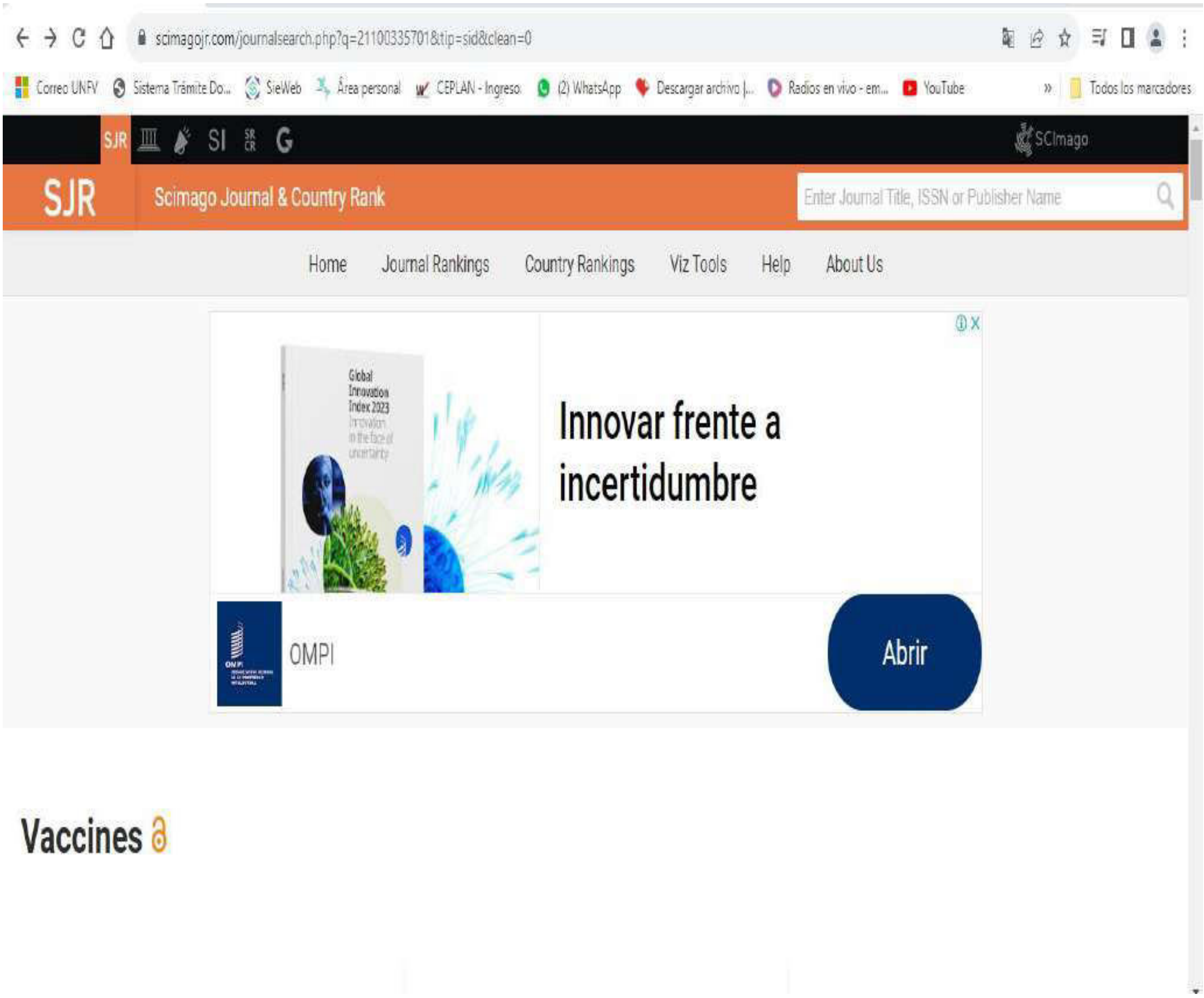
LIMA - PERU

Dr. JOSÉ HECTOR LIVIA SEGOVIA
Director del Instituto Central de Gestión de la Investigación

Folios 37


scimagojr.com/journalsearch.php?q=21100335701&tip=sid&clean=0
Correo UNFV
Sistema Trámite Do...
SieWeb
Área personal
CEPLAN - Ingreso
(2) WhatsApp
Descargar archivo |...
Radios en vivo - em...
YouTube
Todos los marcadores
SJR
SI
SCImago
SJR
Scimago Journal & Country Rank
Enter Journal Title, ISSN or Publisher Name
Home
Journal Rankings
Country Rankings
Viz Tools
Help
About Us
Global Innovation Index 2023
Innovar frente a incertidumbre
OMPI
Abrir
Vaccines

Sistema Integrado de Gestión Administrativa
Módulo de Logística
Versión 23.01.00.U3

Fecha : 22/11/2023
Hora : 16:37
Página : 1 de 1

PEDIDO DE SERVICIO Nº 002844

UNIDAD EJECUTORA : 001 UNIVERSIDAD NACIONAL FEDERICO VILLARREAL
NRO. IDENTIFICACIÓN : 000102

Tipo Uso : Consumo

Dirección Solicitante : VICE RECTORADO DE INVESTIGACIÓN.
Entregar a Sr(a) : AMAYA PINGO PEDRO MANUEL
Fecha : 22/11/2023
Actividad Operativa : C0420 APROBAR Y SUPERVISAR LAS PUBLICACIONES DEL VRIN
Motivo : PUBLICACIONES DE ARTÍCULOS CIENTÍFICOS EN REVISTA INTERNACIONAL, Comparative Epidemiological Assessment of Monkeypox Infections on a Global and Continental Scale Using Logistic and Gompertz Mathematical Models, Dr. Olegario Marín Machuca

FF/Rb	META / MNEMONICO	Función	División Func.	Grupo Func	Programa	Prod/Pry	Act/AI/Obr
2-09	0019	22	006	0007	9001	3999999	5000002

Código	Descripción / Términos de Referencia	Valor S/.	Unidad Medida
150100020007	PUBLICACIONES DE ARTÍCULOS CIENTÍFICOS EN REVISTA INTERNACIONAL	16,900.00	SERVICIO

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Firma del Solicitante

UNIVERSIDAD NACIONAL FEDERICO VILLARREAL
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Firma Autorizada

Universidad Nacional
Federico Villarreal

DIGA

ANEXO 1

SOLICITUD DE FINANCIAMIENTO PARA PUBLICACIÓN (DOCENTES)

Lima de 21 de noviembre del 2023

Señor Vicerrector (a) de la Universidad Nacional Federico Villarreal
Dr. Pedro Manuel Amaya Pingo.

Yo, Olegario Marín Machuca, Docente miembro de la comunidad del conocimiento bajo la modalidad de Grupo de Investigación de Sostenibilidad Ambiental (GISA), adscrito a la Escuela Universitaria de Posgrado de la Universidad Nacional Federico Villarreal (EUPG-UNFV), Nombrado, en la Categoría: Principal a TC, con domicilio en Mz. E, Lote 22. Urb. Los Jardines de San Vicente, distrito de San Juan de Lurigancho, Identificado con código UNFV N° 89085, DNI N° 08810382, e-mail omarin@unfv.edu.pe, en calidad de coautor del artículo:

Comparative Epidemiological Assessment of Monkeypox Infections on a Global and Continental Scale Using Logistic and Gompertz Mathematical Models.

Solicito financiamiento para su publicación en la revista VACCINES/Scopus Índex Journal
Teniendo como autores y coautores:

Obert Marín-Sánchez (autor)
Pedro Pesantes-Grados (coautor)
Luis Pérez-Timaná (coautor)
Olegario Marín-Machuca (coautor)
Christian J. Sánchez-Llatas (coautor)
Ruy D. Chacón (coautor)

Para lo cual adjunto el artículo, la aceptación, certificado de aceptación y el costo para su publicación en dicha revista.

Atentamente,

Dr. Olegario Marín Machuca
Docente responsable

FORMATO N° 01

TÉRMINOS DE REFERENCIA PARA SERVICIOS

1. **ÁREA USUARIA**
   Instituto Central de Gestión de la Investigación
2. **DENOMINACIÓN DE LA CONTRATACIÓN**
   Servicio de publicación de artículo científico en revista indizada internacional
3. **FINALIDAD PÚBLICA**
   El Instituto Central de Gestión de la Investigación tiene como parte de sus funciones, promover la investigación, producción científica, innovación y emprendimiento de los docentes y estudiantes de la Universidad Nacional Federico Villarreal, estableciendo estrategias que coadyuven a cumplir con las metas propuestas.
   Debiendo contar para ello con la evidencia necesaria de las múltiples investigaciones que realizan los docentes y estudiantes de la comunidad villarrealina, a través de la publicación de los artículos en revistas indexadas de alto impacto a nivel internacional.

4. **ANTECEDENTES**
   En el marco de las estrategias establecidas nuestra casa de estudios ha a través de sus recursos directamente recaudados otorgara financiamiento por servicio de publicación de artículos científicos en revistas especializadas e indexadas a nivel internacional. R. R. N° 236-2022-UNFV San Miguel, 28 abril de 2022. Directiva LINEAMIENTOS Y PROCEDIMIENTOS PARA EL ACCESO AL FINANCIAMIENTO DEL SERVICIO DE LAS PUBLICACIONES EN REVISTAS INDIZADAS, (web of science, scopus, scielo).

5. **OBJETIVO DE LA CONTRATACIÓN**
   Financiar el servicio de publicación de artículos científicos en una revista indexada a nivel Internacional.

6. **REQUERIMIENTO, CARACTERÍSTICAS Y CONDICIONES**

6.1. REQUERIMIENTO

N° Ítem	Código Siga	Descripción del servicio	Unidad de Medida	Cantidad
01	02844	Publicación de Articulo en Revista Científica	Servicio	01

6.2. CARACTERÍSTICAS DE LA REVISTA

Deberá ser una revista científica de investigación a nivel internacional.
Deberá tener publicaciones mensuales y acceso libre e inmediato a su contenido a través de las páginas web.
La revista deberá figurar en las bases de datos especializadas en revistas científicas indexadas,como: scopus, web of science, scielo.

6.3. RESPONSABILIDAD DEL CONTRATISTA

6.3.1. Plazo de reposición

En caso de detectarse errores ortográficos y/o gramaticales, luego de la publicación del artículo en la revista indizada, el área usuaria dentro de los dos (02) días hábiles siguientes de realizada la publicación, solicitará a través de la Oficina de Abastecimiento y Servicios Generales, se notifique al proveedor el sentido de las observaciones y el plazo para su reposición (nueva publicación).

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INSTITUTO CENTRAL DE GESTIÓN DE LA INVESTIGACIÓN

6.3.2. Garantía comercial

El proveedor otorgará una garantía comercial para avalar que el servicio prestado cumple con todas las características y condiciones establecidasen los términos de referencia, el cual no podrá ser menor a un (01) año, computados a partir de la entrega de la Constancia del artículo publicado.

Para lo cual una vez identificado el servicio que presenta defectos, se notificará al proveedor para su reposición inmediata en un plazo máximode tres (03) días calendarios computados luego de la notificación de la carta por parte de la Oficina de Abastecimiento.

6.3.3. Responsabilidad por vicios ocultos

El plazo máximo de responsabilidad del contratista es de un (01) año, contado apartir de la conformidad otorgada por la Entidad.

6.4. LUGAR DONDE SE EJECUTARÁ LA PRESTACIÓN

No aplica

6.5. CONDICIONES DE LA PRESTACIÓN

La publicación se realizará a través de una plataforma especializada de forma virtual,de acuerdo a las condiciones establecidas por el proveedor.

6.6. PLAZO DE EJECUCIÓN DE LA PRESTACIÓN

Entregable	Plazo
Constancia del artículo publicado	Hasta cien (100) días calendario siguientes, computados a partir del día siguiente de recibido el pago correspondiente.

6.7. FORMA DE PAGO

La Entidad debe pagar las contraprestaciones pactadas a favor del contratista de forma previa en pago único, a la publicación de articulo por derecho a la revista indexada, siempre que se verifiquen las condiciones establecidas en los términos de referencia y previa presentación del Formato N° 04 - Autorización para realizar el pago previo a la publicación por derecho a la revista indexada, por parte del área usuaria

6.8. CONFORMIDAD

La conformidad de la prestación será dada expresamente por el Director del Instituto Central de Gestión de la Investigación - ICGI de la UNFV, dentro de los dos (02) días hábiles siguientes de la verificación y cumplimiento de la prestación de acuerdo al requerimiento y la orden de servicio.

6.9. PENALIDADES

No aplica.

6.10. CONFIDENCIALIDAD

El proveedor deberá guardar absoluta confidencialidad en el manejo de la información y documentación a la que tenga acceso durante la prestación del servicio, no podrá revelar detalles sobre el alcance del servicio a terceros, excepto cuando resulte estrictamente necesario para el cumplimiento de la prestación. En ambos casos el proveedor deberá dar cumplimiento y será responsable de la aplicación a todas las políticas definidas por UNFV en materia de seguridad de la información.

6.11. VICIOS OCULTOS

El plazo máximo de responsabilidad del contratista es de un (01) año, contado a partir de la conformidad otorgada por la Entidad.

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6.12. NORMATIVA ESPECÍFICA

No aplica

6.13. ANEXOS U OTROS DOCUMENTOS EN RELACIÓN CON LA CONTRATACIÓN.

- Carta de aceptación remitida por el proveedor.
- invoice remitida por el proveedor.
- Formato de Validación de los Términos de Referencia.
- Formato de Conversión de moneda y Cálculo de obligaciones tributarias.
- Formato de Autorización para realizar el pago previo a la publicación porderecho a la revista indexada, de ser caso.
- Ficha técnica de la revista.
  El articulo a publicar en formato digital.

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OFICINA DE PROYECTOS DE INVESTIGACIÓN
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FORMATO N° 2
VALIDACIÓN DE LOS TÉRMINOS DE REFERENCIA

Revisión y/o verificación del cumplimiento de los Términos de Referencia

1	DENOMINACIÓN DE LA CONTRATACIÓN	"Publicación de artículo en revista científica"
2	DEPENDENCIA USUARIA	VICERRECTORADO DE INVESTIGACION

ÍTEM N°	DESCRIPCIÓN DEL ÍTEM			PROVEEDOR	
	Descripción clara y precisa del objeto de la contratación	Cantidad	Cumple	Razón Social	VACCINES
	Deberá ser una revista científica de investigación a nivel internacional	1	SI	RUC	PROVEEDOR DEL EXTRANJERO
	La editorial dueña de la revista debe tener varias publicaciones especializadas en enseñanza multicultural	1	SI	Número de Cotización / Invoice / Factura / Órden	2686226
	La revista debe figurar en las bases de datos especializadas en revistas científicas indexadas como: Scopus, Web of Sciences, Scielo		SI	Fecha del documento remitido	20/11/2023
				Otros (pais proveedor)	SUIZA

3	NOTAS / OBSERVACIONES	SE REQUIERE EL PAGO PREVIO
4	FECHA DE ELABORACIÓN DEL DOCUMENTO:	22/11/2023
5	EMITIDO Y APROBADO POR:	

UNIVERSIDAD NACIONAL FEDERICO VILLARREAL
INSTITUTO CENTRAL DE GESTIÓN DE LA INVESTIGACIÓN
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UNIVERSIDAD NACIONAL FEDERICO VILLARREAL
OFICINA DE PROYECTOS DE INVESTIGACIÓN
INSTITUTO CENTRAL DE GESTIÓN DE LA INVESTIGACIÓN

FORMATO Nº 3

CONVERSIÓN DE MONEDA Y CÁLCULO DE OBLIGACIONES TRIBUTARIAS

1	**DENOMINACIÓN DE LA CONTRATACIÓN**	"Publicación de artículo en revista científica"			
2	**DEPENDENCIA USUARIA**	VICERRECTORADO DE INVESTIGACION			
3	**DATOS DEL PROVEEDOR**				
	Razón Social	**VACCINES**			
	RUC	**PROVEEDOR DEL EXTRANJERO**			
	Número de Cotización / Invoice / Factura / Órden	**2686226**			
	Fecha del documento remitido	**20/11/2023**			
	Moneda y monto del importe	**Moneda del importe:**	**FRANCO SUIZOS**	**Monto del importe:**	**2,430.00**

4	**CALCULO DE PAGO**	
	Moneda y monto del importe	**CHF 2,430.00**
	Tipo de cambio SBS al día 21.11.2023	**S/ 4.665**
	Moneda y monto del importe según conversión	**S/ 11,335.95**
	Calculo de pago IGV no domiciliado (18%)	**S/ 2,040.47**
	Periodo en que se realiza el calculo de pago IGV no domiciliado	**Nov-23**
	Retenciones (30%) según sea el caso	**S/ 3,400.78**
	Gastos operativos / Comisiones	**S/ 122.80**
	IMPORTE TOTAL PARA CERTIFICAR	**S/ 16,900.00**

5	**NOTA:**	Para la contratación de servicios con proveedores no domiciliados en el país, se aplicarán las normas tributarias y tratados internacionales correspondientes y vigentes a la fecha de elaboración de presente documento.
6	**FECHA DE ELABORACIÓN DEL DOCUMENTO:**	**22/11/2023**
7	**EMITIDO Y APROBADO POR:** Director del ICGI - Dr: Jose Hector Livia Segovia	**Dra. Graciela Martina Monroy Correa**

UNIVERSIDAD NACIONAL FEDERICO VILLARREAL
INSTITUTO CENTRAL DE GESTIÓN DE LA INVESTIGACIÓN
LIMA - PERÚ

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OFICINA DE PROYECTOS DE INVESTIGACIÓN
INSTITUTO CENTRAL DE GESTIÓN DE LA INVESTIGACIÓN

FORMATO Nº 4

AUTORIZACIÓN PARA REALIZAR EL PAGO PREVIO A LA PUBLICACIÓN POR DERECHO A LA REVISTA INDEXADA

1	**FECHA DE EMISIÓN DEL DOCUMENTO**		20/11/2023
2	**DEPENDENCIA USUARIA**		VICERRECTORADO DE INVESTIGACION
3	**DATOS DEL PROVEEDOR**	Razón Social	VACCINES
		RUC / Código	PROVEEDOR DEL EXTRANJERO
		Dirección	St. Alban-Anlage 66- 4052 Basel Switzerland
		Nombre de contacto	Ms. Helmi Qi
		Número telefónico	Tel: +41 61 683 77 34
		E-mail	billing@mdpi.com
4	**DATOS DE LA CONTRATACIÓN**	ítem	1
		Descripción del objeto de la contratación	"SERVICIO DE PUBLICACIÓN DE ARTÍCULO EN REVISTA INDIZADA INTERNACIONAL"
		Monto de la contratación	S/.16,900.00
		Forma de pago	PAGO PREVIO
		Plazo de la prestación	HASTA CIEN DIAS CALENDARIOS SIGUIENTES CONTADOS A PARTIRDEL DIA SIGUIENTE DE RECIBIDO EL PAGO CORRESPONDIENTE
		Validación de TdR	SEGÚN FORMATO ADJUNTO
6	**OBSERVACIONES**		
	PROVEEDOR CON SEDE SUIZA		
7	**AUTORIZACIÓN EN CASO DE REALIZAR EL PAGO PREVIO A LA PUBLICACIÓN**		
	El funcionario que suscribe el presente documento, dada la naturaleza de la contratación autoriza la realización del pago previo a la publicación, a fin de alcanzar la finalidad de la contratación.		
	CONDICIONES PARA EL PAGO PREVIO	Monto a pagar	S/.16,900.00
		Plazo para realizar el pago	25 DIAS CALENDARIO
		Nombre y dirección del banco destino	UBS Switzerland AG, Bahnhofstrasse 45 8001 Zürich Switzerland
		Nombre de cuenta	MDPI AG
		Número de cuenta	0233 00222721.01Y
		CCI / Código Swift	UBSWCHZH80A
		Código ABA / IBAN	CH74 0023 3233 2227 2101 Y
		Otras consideraciones	Tenga en cuenta que la tarifa por usar PayPal es del 5% del monto facturado.
8	V° B° Dr. José E. Livia Segovia Director – ICGI UNIVERSIDAD NACIONAL FEDERICO VILLARREAL – INSTITUTO CENTRAL DE GESTIÓN DE LA INVESTIGACIÓN – LIMA - PERÚ		UNIVERSIDAD NACIONAL FEDERICO VILLARREAL – OFICINA DE PROYECTOS DE INVESTIGACIÓN – INSTITUTO CENTRAL DE GESTIÓN DE LA INVESTIGACIÓN Dra. Graciela Martina Monroy Correa
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Comparative Epidemiological Assessment of Monkeypox Infections on a Global and Continental Scale Using Logistic and Gompertz Mathematical Models

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Abstract: The monkeypox virus (MPXV) has caused an unusual epidemiological scenario—an epidemic within a pandemic (COVID-19). Despite the inherent evolutionary and adaptive capacity of poxviruses, one of the potential triggers for the emergence of this epidemic was the change in the status of orthopoxvirus vaccination and eradication programs. This epidemic outbreak of HMPX spread worldwide, with a notable frequency in Europe, North America, and South America. Due to these particularities, the objective of the present study was to assess and compare the cases of HMPX in these geographical regions through logistic and Gompertz mathematical modeling over one year since its inception. We estimated the highest contagion rates (people per day) of 690, 230, 278, and 206 for the World, Europe, North America, and South America, respectively, in the logistic model. The equivalent values for the Gompertz model were 696, 268, 308, and 202 for the highest contagion rates. The Kruskal-Wallis Test indicated different means among the HMPX geographical regions regarding case velocity, and the Wilcoxon pairwise test indicated the absence of significant differences between the case velocity means among Europe and South America. The coefficient of determination (R^2) values in the logistic model varied from 0.8720 to 0. The coefficient of determination (R^2) values in the logistic model varied from 0.8720 to 0.9023, and in the Gompertz model, they ranged from 0.9881 to 0.9988, indicating a better fit to the actual data with the Gompertz model. The estimated basic reproduction numbers (R_0) were more consistent with the logistic model, varying from 1.71 to 1.94 by the graphical method and from 1.75 to 1.95 by the analytical method. The comparative assessment of these mathematical modeling approaches permitted the establishment of the Gompertz model as the better-fitting model for the data and the logistic model for the R_0. However, both models successfully represented the actual HMPX case data. The present study estimated relevant epidemiological data to understand better the geographic similarities and differences in the dynamics of HMPX.

Keywords: basic reproduction number; cases; coefficient of determination; critical time; Gompertz function; logistic regression; mathematical modeling; monkeypox

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1. Introduction

The monkeypox (also known as Mpox) virus (MPXV) is a zoonotic virus with similar clinical features to smallpox. MPXV belongs to the family *Poxviridae*, and the viral particle is a brick-shaped enveloped virion of 150-300 nm size that contains a double-stranded D.N.A. genome of 200 kbp on average [1]. Although the isolation source of MPXV resides among animals, it is still undetermined the viral host reservoirs and infection occur in several species such as mice, rats, rabbits, hamsters, monkeys, humans, prairie dogs, woodchucks, jerboas, and porcupines [2].

The virus was initially isolated in 1958 from vesiculopustular lesions found in fever monkeys (*Java macaques*) in Denmark. However, the first recorded human monkeypox (HMPX) infection occurred in 1970 in the Democratic Republic of the Congo, followed by sporadic outbreaks in eight African countries between 1970 and 1999, resulting in approximately 923 HMPX cases [3]. The first instance of HMPX outside Africa was reported in 2003 in the United States, with 47 cases. Between 2000 and 2020, a total of 20,237 cases of HMPX were reported across 16 countries [4]. Although MPXV had been primarily confined to African countries with occasional outbreaks elsewhere, in May 2022, a case of HMPX was documented in the United Kingdom. From that point until February 2023, the virus has rapidly spread to over 100 countries, leading to a total of 85,536 confirmed cases, with most cases concentrated in Europe, the U.S.A., and South America [5].

MPXV zoonotic transmission occurs through direct contact or consumption of infected animals. Human-to-human transmission usually takes place through indirect contact with respiratory secretions, skin lesions, or contaminated objects. However, direct contact remains a well-known risk factor for transmission [6]. MPXV infection causes a self-limiting disease with an incubation period of 4-14 days, and it is characterized by headache, malaise, backache, fatigue, lethargy, and low-grade fever. The vesiculopustular rash on the face and trunk appears 12-26 days after exposure, and the worst clinical outcomes, such as bronchopneumonia, encephalitis, and visual loss, are expressed in immunocompromised patients [6].

Since eradicating smallpox using the vaccinia virus in 1980, nearly four decades have passed without any orthopoxvirus vaccination programs. Consequently, discontinuing smallpox vaccination may have contributed to a reduction or even loss of herd immunity against HMPX, potentially leading to an increase in the spread of the virus [7]. At present, the treatment for HMPX is primarily supportive, and antiviral medications like tecovirimat, cidofovir, and brincidofovir come with serious adverse effects. Additionally, only three FDA-approved vaccines have shown efficacy in clinical trials; however, there is currently no available data on their real-world effectiveness [8]. The long-term and rapid transmission in non-endemic regions worldwide has raised concerns about the potential evolution of MPXV into a more lethal pathogen. Moreover, the lack of treatment emphasizes the need for strategies to enhance epidemiological tracking and reckoning [9].

Since the 1920s, mathematical modeling approaches have been developed to understand dynamic growth and viral transmission patterns [10]. Logistic-regression-based models have been proposed for detecting and predicting epidemiology patterns in COVID-19, showing similar results between the dynamics of the virus in a real scenario and those calculated by the model [11–13]. In mathematical modeling based on a differential equation, along with the logistic model, there is another widely used in population growth dynamics: the so-called Gompertz model, which has been widely used in tumor and epidemiological growth. Gompertz initially proposed this model in 1825 to study mortality in human populations. Since it was used by Casey in 1934 for the adjustment of tumor growth curves [14,15], its use in mathematical oncology has been ubiquitous because the solution curve of the differential equation of Gompertz gives us the ability to model a saturated growth and with a nonsymmetric inflection point compared to the logistic model whose sigmoid curve is symmetrical [16,17]. In epidemiology, it has been used along with other models such as the generalized logistic, Von Bertalanffy, and

Richards, among others, for the adjustment of curves of the population of people affected by COVID-19, for example [18,19].

Infection with the MPXV has previously been modeled using systems of ordinary first-order differential equations [20,21] and fractional order [22,23], which have considered both interaction with a sink for zoonotic transmission (rodents) as well as dissemination among the human population in some cases isolation of the sick and vaccination which provides permanent immunity have been considered. Although models based on systems of differential equations provide a much more detailed explanation of the mechanisms of population propagation and allow us to simultaneously evaluate several epidemiological populations in addition to those infected as susceptible, latent, or recovered, models that characterize a single population, have been shown to fit well with the data in some studies [18,24,25].

This study aimed to assess and compare the cases of HMPX in distinct continental regions through logistic and Gompertz differential equations over 12 months of the epidemic. In addition, we estimated the primary reproduction number for each model.

2. Materials and Methods

2.1. Data Collection

The primary dataset used to analyze Monkeypox infections in the present study was obtained from the World Health Organization's (WHO) comprehensive report on global trends in Monkeypox for 2022-23 [26]. The data variable under investigation pertained to the aggregate number of cases or infections, wherein "total cases" was defined as the sum of confirmed Monkeypox cases within the specified time frame from May 1, 2022, to April 30, 2023.

To elucidate the epidemiological landscape of Monkeypox, a graphical representation was employed to illustrate the temporal evolution of the disease across the World and the continents with the highest incidence rates, namely Europe, North America, and South America. A comprehensive global overview was presented, treating it as a single entity for the specified time interval.

2.2. Mathematical Modeling

The mathematical modeling of the monkeypox time series considering the variable of cases (or diagnosed infected people) was carried out using the logistic regression and the Gompertz function. These models use the sigmoid function to describe the growth of a variable with slower speeds at the beginning and end of a period.

The R programming language within the R Studio integrated development environment (IDE) incorporates various packages, including but not limited to tidyverse and ggplot2, as outlined in subsequent sections. These packages were used to visualize and model the results obtained [27].

2.2.1. Logistic Model

The foundation of this model was rooted in the empirical modeling framework posited by Bronshtein and Semendiaev, and it was derived as an extension of the Verhulst-Pearl logistic model [28,29]. In the context of this research, this model was employed to assess and project the temporal patterns of Monkeypox cases within specific geographical regions, namely the World, Europe, North America, and South America.

The mathematical expression used to quantify the temporal dynamics of Monkeypox within these defined populations can be characterized as a logistic dispersion, and it is formulated as follows:

$$N = \frac{M}{(1 + Q \times e^{-k \times t})} \quad (1)$$

In this mathematical representation, the symbol "M" signifies the maximum capacity for the occurrence of cases, "Q" denotes a pre-established constant, "k" represents a factor of proportionality, "t" signifies the elapsed time measured in days, and "N" represents the count of observed cases.

The formula utilized to calculate the maximum capacity "M" for the three distinct events necessitates the consideration of three independent stochastic variables, along with their associated dependent values retrieved from the dataset. This computation is performed according to the following mathematical expression [13]:

$$M = \frac{A \times B - I^2}{A + B - 2} \quad (2)$$

The initial value denoted as "A" corresponds to the dependent variable at the inflection point of the independent variable "t_1". If the computed inflection point (mean value) is not a whole number, it is rounded to the next highest available integer value. This rounding rule will be used similarly for the following parameters and will include any linked value. The second value, designated as "B," represents the dependent variable value corresponding to the final value of the independent variable "t_2". The third value, denoted as "I," is associated with the dependent variable value related to the semi-sum of the independent variables "t_1" and "t_2," expressed as "$t_3=(t_1+t_2)/2$". Subsequently, the ascertained value of "M" is inserted into the logistic model. The logistic model is then subjected to mathematical linearization, and the least squares method is employed to achieve the following form: $ln\,(\frac{M}{N} - 1) = ln\,Q + k \times t$; a linear equation: $y = A + Cx$, where $y = ln\,(\frac{M}{N} - 1)$, $x = t$, and $A = ln\,Q$.

In the context of executing the statistical procedure of linear regression, which involves inputting paired data points (x, y) $[t, ln\,(\frac{M}{N} - 1)]$, and upon entering all the data pairs to determine the values of $ln\,Q$ and k, where k represents the slope of the linear equation (specifically, the 'C' coefficient in the equation:: $y = A + Cx$, with A being lnB and thus, $Q = e^A$. This is achieved by deriving Equation (1), leading to the establishment of Equation (3). Equation (2) is then employed to ascertain the maximum possible number of infected individuals (M), a crucial value for subsequent calculations. To gauge the incidence rate of Monkeypox cases within the specified populations, we deduce the established logistic model, characterized by the following mathematical representation:

$$\frac{dN}{dt} = [\frac{M \times Q \times k \times e^{-k \times t}}{(1 + Q \times e^{-k \times t})^2}] \quad (3)$$

To ascertain the critical time point denoted as (t_c), corresponding to the moment when the count of Monkeypox cases reaches its peak, we derive equation (3), equal it to zero, and subsequently solve for (t_c):

$$t_c = -\frac{1}{k} \times ln\,(\frac{1}{Q}) \quad (4)$$

2.2.2. Gompertz Model

The Gompertz model assumes that a population's growth rate is dense-dependent, that is, that the number of individuals in a later instant depends on the number of individuals previously, and the higher the initial number of individuals will be their growth rate. It is also part of the models formalized in ordinary differential equations whose solutions are sigmoid functions and, in the particular case that we present, depends on three parameters for further adjustment, whose main characteristic is that the turning point of the curve is located before the midpoint of the curve, which gives it an asymmetrical aspect and can reflect processes where exponential growth occurs in early stages of the epidemic and then slows down [14,24].

The Gompertz differential equation can be posed as a modification of the logistic equation, given by $\frac{dN}{dt} = rN\,(1 - \frac{ln(N)}{ln(\alpha)})$, where is the infection rate (day^{-1}), α is the maximum cumulative number of infected people in each region, and $N=N(t)$ is the cumulative number of infected from the onset of the epidemic to time t (in days). Rewriting the equation, we have to: $\frac{dN}{dt} = rN\,(1 - \frac{ln(N)}{ln(\alpha)}) = rN\,(\frac{\ln(\alpha)-\ln(N)}{\ln(\alpha)}) = \frac{r}{\ln(\alpha)}N \cdot ln\,(\frac{\alpha}{N})$, by making a change of variable $\gamma = \frac{r}{\ln(\alpha)}$, we can express: $\frac{dN}{dt} = \gamma \cdot N \cdot ln\,(\frac{\alpha}{N})$, where γ is the constant of proportionality related to the growth rate of the epidemic. Therefore, we can present the initial value problem as:

$$\frac{dN}{dt} = \gamma \cdot N \cdot ln\,(\frac{\alpha}{N}), \qquad t(0) = t_0, N(t_0) = N_0, \tag{5}$$

where t_0 is a point of reference from the beginning of the epidemic and $N_0 > 0$ is the amount of infected accumulated at the beginning of the infection over time t_0. The analytical solution of the differential equation (5) is as follows:

$$N(t) = N = \alpha \cdot e^{-\,ln(\frac{\alpha}{N_0})\cdot e^{-\gamma t}} \tag{6}$$

Making an additional variable change: $\beta = ln\,(\frac{\alpha}{N_0})$, where β is a parameter that controls how quickly the population approaches α. The higher it is β, the faster the population will approach the maximum asymptotic value of α. From which we can express the Gompertz function as:

$$N(t) = N = \alpha e^{-\beta e^{-\gamma t}} \tag{7}$$

The function found in (7) will be our curve, to which we will adjust the selected data to apply the same methodology to determine parameters as in the logistic model. The value of α was calculated using the mean values described by Bronshtein & Semendiaev, while the parameters β and γ were obtained by linear regression [30].

Taking natural logarithm to (7), we obtained,

$$N\,ln(N) = ln\alpha - \beta e^{-\gamma t} \tag{8}$$

$$ln(N) - ln\alpha = -\beta e^{-\gamma t}$$

Making the following variable change,

$$y = ln(N)\,, c = ln\alpha \tag{9}$$

$$y - c = -\beta e^{-\gamma t}$$

And linearizing,

$$ln(y - c) = ln(-\beta) - \gamma t$$

If we have three points representing the epidemiological data of accumulated infected:(t_1,y_1),(t_2,y_2),(t_3,y_3), we can estimate the parameter c [30].

$$c = \frac{y_1 y_2 - y_3^2}{y_1 + y_2 - 2y_3} \tag{10}$$

By reversing the variable changes of (8) and taking the same three points as those considered for the logistics model (t_1, A),(t_2, B),(t_3, I), where $t_3=(t_1+t_2)/2$, we must replace in (10), we can calculate the value of α :

$$ln\alpha = \frac{ln(A)\,ln(B) - ln^2(I)}{ln(A) + ln(B) - 2\,ln(I)}$$

$$\alpha = e^{(\frac{ln(A)\,ln(B) - ln^2(I)}{ln(A) + ln(B) - 2\,ln(I)})} \tag{11}$$

On the other hand, from the expression (8) we must:

$$ln\alpha - ln(N) = \beta e^{-\gamma t}$$

$$\ln\left(\frac{\alpha}{N}\right) = \beta e^{-\gamma t}$$

Linearizing, we get:

$$\ln\left(ln\left(\frac{\alpha}{N}\right)\right) = ln\beta - \gamma t \quad (12)$$

From the second linearization equation (12) and applying the least squares method approach with the line $Y = a + bX$, where $Y = \ln\left(ln\left(\frac{\alpha}{N}\right)\right), X = t, b = -\gamma$, and $a = ln\,(\beta)$, it is possible to find the values of the parameters α and γ of the Gompertz equation.

For estimating parameters by linear regression, the data were tabulated as ordered pairs (t, N), and the values of $Y = ln\left(ln\left(\frac{\alpha}{N}\right)\right)$ as X=t were calculated directly from the estimated line, the values of $\gamma = -b$, and as $a = ln(\beta)$, then $\beta = e^{a}$.

To estimate the rate of cases due to Monkeypox in all study populations, the Gompertz function was derived, and its differential equation was found:

$$\frac{dN}{dt} = \alpha\beta\gamma e^{-\beta e^{-\gamma t} - \gamma t}$$

In order to determine the critical value (t_c), which represents the maximum value of the daily cases observed in the data, the second derivative was calculated, which has the form:

$$\frac{d^2N}{dt^2} = \alpha\beta\gamma e^{-\beta e^{-\gamma t} - \gamma t}(\beta\gamma e^{-\gamma t} - \gamma) \quad (13)$$

Moreover, the expression (13) was equal to zero, which represents geometrically the time coordinate of the inflection point of the Gompertz curve of the accumulated cases (data), obtaining:

$$t_c = \frac{ln(\beta)}{\gamma}$$

If the value obtained is not an integer, the following integer value is selected (through rounding), and then this value serves as a reference to find the date and maximum daily infection rate value in the data.

2.3. Statistical Analysis

In the R programming language, we utilized additional packages within the R Studio integrated development (IDE) environment, namely Nortest and Stats. The Nortest package comprises a set of R functions tailored for executing normality tests, while the Stats package encompasses a range of R functions dedicated to statistical tests and comprehensive data analysis. Additionally, for model validation, we employed the lmtest package to conduct the Breusch-Pagan test.

2.3.1. Normality Tests for the Variable Cases

The Monkeypox Total Cases variable underwent a segmentation process for statistical analysis, stratified according to the respective population groups under investigation, and categorized by geographical regions (i.e., World, Europe, North America, South America). This segmentation was performed to determine the most appropriate statistical tests to be subsequently applied to the dataset for both the logistic model and the Gompertz model.

Hypothesis tests were conducted to assess the normality of the data within each group. These tests were designed to ascertain whether the data distribution in each group adheres to a normal distribution. The outcome of these tests is represented by a p-value, which quantifies the probability of observing a data distribution like or deviating further from normality. This is done assuming the null hypothesis posits that the variable conforms to a perfectly normal distribution within the population [31]. In cases where the p-value exceeds the predetermined significance level, inadequate evidence exists to reject the null hypothesis. This suggests that the variable follows a normal distribution [31].

The Kolmogorov-Smirnov test was employed because the dataset within each population group exceeded a sample size of N > 50. This test used the lillie—test function from the nortest package for each population.

Hypothesis Test:
H_0: The data follows a normal distribution.
H_1: The data does not follow a normal distribution.

A significance level (α) of 0.05 was established.

2.3.2. Kruskal-Wallis Test for Monkeypox Cases Velocity

Based on the normality test results, the Kruskal-Wallis test was conducted for both the logistic and Gompertz models. This non-parametric test assesses differences among three or more independent groups sampled from a single non-normally distributed continuous variable [32]. To perform the test, the Kruskal.test(case velocity ~ geographic region, data = monkeypox) function was used.

Hypothesis Test:
H_0: No significant differences among the means of the populations under study exist.
H_1: At least one mean significantly differs from the other populations.

A significance level (α) of 0.05 was established.

2.3.3. Post-Hoc Test: Pairwise Wilcoxon Test for Monkeypox Cases Velocity

Based on the results of the Kruskal-Wallis test, a post-hoc test was conducted to determine which means exhibit significant differences for both the logistic model and the Gompertz model. As a post-hoc test for the Kruskal-Wallis test, multiple non-parametric pairwise comparisons are typically performed, often using the pairwise Wilcoxon test [33]. To conduct the test, the pairwise. wilcox.test(case velocity ~ geographic region, data = monkeypox) function was employed.

Hypothesis Test for each combination:
H_0: No significant differences exist between the means of populations X and Y.
H_1: There are significant differences between populations X and Y.

X and Y represent any pair of populations analyzed by the Wilcoxon test.

A significance level (α) of 0.05 was established.

2.3.4. Multiple Linear Regression Analysis for Monkeypox Cases Velocity

Additionally, a multiple linear regression test was conducted to assess the effect of each geographic region on the velocity of monkeypox cases and to validate the conclusions drawn from the Kruskal-Wallis and Wilcoxon tests for the logistic model and the Gompertz model. Time and geographic region were used as independent variables to determine if they are explanatory in the multiple linear regression model [34]; in other words, if they affect the velocity of monkeypox cases. The lm(case velocity ~ time + geographic region, data = monkeypox) function was utilized to perform the test.

Hypothesis Test for each geographic region:

H_0: Geographic region does not affect the velocity of Monkeypox cases.
H_1: Geographic region affects the velocity of Monkeypox cases.

The geographic regions are Europe, North America, and South America.

A significance level (α) of 0.05 was established.

2.3.5. Comparison of Modeled Variable against Real Data

To assess the degree to which the mathematical models align with the empirical data, we computed the coefficient of determination denoted as R^2, as elaborated by Schober, et al., [35] for both the logistic model and the Gompertz model. R^2 indicates the proportion of the total variability observed in the response variable that the model can elucidate. A higher R^2 value, approaching 1, signifies a robust model fit, implying that the model can account for a substantial portion of the response variable's variability. Conversely, a lower R^2 value, approaching 0, implies that the model inadequately explains the variability inherent in the response variable.

To calculate R^2, we employed the subsequent mathematical formula: R^2=1-(SSR/SST), where S.S.R. (Sum of Squares Residual) represents the summation of squared discrepancies between the predicted values derived from the model and the actual values of the response variable. At the same time, S.S.T. (Sum of Squares Total) signifies the summation of squared discrepancies between the actual values of the response variable and its mean.

Additionally, the Akaike information criterion (A.I.C.) was used as a second metric to analyze the goodness of fit of our models to the actual data. This criterion evaluates the quality of the adjustment of the models considering the number of parameters used in each model and the number of observations made, choosing the best model that minimizes the A.I.C. index. This index is calculated as [18]:

$$AIC = n \cdot ln \left(\frac{\sum_{i=1}^{n} (y_i - \hat{y})^2}{n} \right) + 2 \cdot p$$

Where n is the amount of data analyzed (in our case, 365 days), p is the number of parameters of our model (p=3, for both models), and the difference of residuals squared is given between the observed values (actual data) y_i and the predicted values for each of the models $\hat{y}_i$. This index was estimated after tabulating accumulated data for the infected population (actual data, estimated data from the logistic and Gompertz models). Three parameters were estimated for the logistics model (M, A, k) and the Gompertz model (α,β,γ).

2.4. Estimation of the Basic Reproduction Number

The primary reproduction number is a relevant epidemiological parameter at the beginning of an epidemic outbreak; it indicates the number of secondary infections that can occur when an infected individual is in contact with a population susceptible to infection. Its epidemiological interpretation means for R_0>1, the disease will spread, while for R_0<1, the outbreak will tend to limit itself. Aware of the importance of this epidemiological parameter, we employed two different approaches to estimate it using the data obtained from the two mathematical models in the present study. This was done to evaluate which of these approaches could better reflect a real scenario. In our case, we estimate R_0 values for both models using two empirical methods. To implement them, we need to know the infectious time and incubation period (pre-infectious period) of the disease. Then, we estimate the value of R_0 using the following formula [36]:

$$R_0 = (1 + r \cdot D)(1 + r \cdot D') \qquad (14)$$

where r is the growth rate of the epidemic, D is the average time of infection, and D' is the average incubation time. This approach is valid when we assume that D and D'

follow an exponential distribution and when D and D' are relatively short compared to each other.

The first methodology presented by [36] is a graphical method by which we tabulate the first 26 days of the epidemic (considering the quasi-exponential behavior in the early stages of the epidemic outbreak) concerning the natural logarithm of the accumulated data and by linear regression we estimate the growth rate of the epidemic "r" (intrinsic growth of the infected population per each model) as the slope of the straight. The obtained values for r are then utilized in equation (14).

The second methodology used is an analytical approach, since at the beginning of an epidemic, the number of infected persons accumulated is much lower than their maximum capacity, $N \ll$ N_max; therefore, it is possible to approximate a logistic or Gompertz function to exponential growth.

In the case of the differential logistic equation $\frac{dQ}{dt} = kQ\,(1 - \frac{Q}{M})$, when $Q < M$, Q/M tends to zero, and therefore $dQ/dt = rQ$, whose solution is $Q(t) = Q(0)e^{kt}$, where $r_{logistic} = k$ is the intrinsic growth rate of the epidemic "r".

For the Gompertz model $\frac{dN}{dt} = \gamma N ln\,(\frac{\alpha}{N})$, we can approximate $ln(\alpha/N)$ by a Taylor series: $ln(\alpha/N) = ln(\alpha) - N/\alpha$. So, $dN/dt = \gamma N(ln(\alpha) - N/\alpha)$, and when $N < \alpha$, then $dN/dt = \gamma ln(\alpha)N$. The solution is $N(t) = N(0)e^{\gamma ln(\alpha)t}$, where $r_{gompertz} = \gamma ln(\alpha) = r$. The obtained values for r are then utilized in equation (14).

3. Results

3.1. *Epidemiological Panorama of Monkeypox*

The monkeypox outbreak that began in May 2022 accumulated more than 87 thousand cases worldwide until this study's analysis date (April 30, 2023). Worldwide, the maximum values of daily cases were recorded between August 24 and October 5, 2022, exceeding 1650 cases per day. In the case of the continents, the maximum case values were recorded in 2022, between July 10 to August 2 (for Europe), August 10 to 24 (for North America), and between August 9 to October 12 (for South America), with maximum values exceeding 860, 1450 and 620 cases per day, respectively (Figure 1). Consequently, the accumulated case values as of the cut-off date were more than 87.2 thousand (World), 25.6 thousand (Europe), 36.9 thousand (North America), and 22.3 thousand (South America).

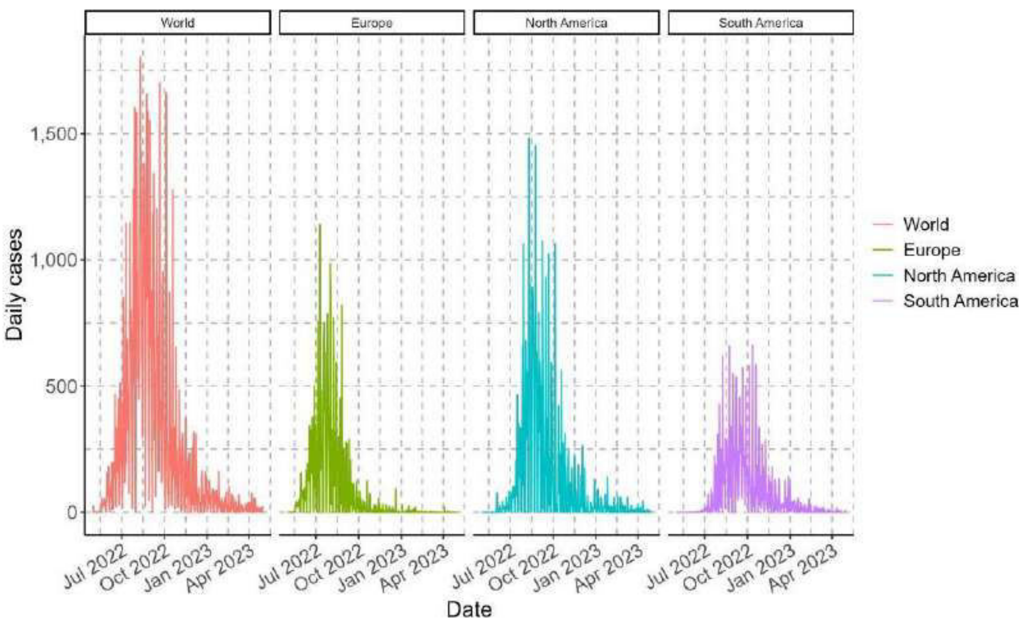


Figure 1. Epidemiological overview of Monkeypox daily cases for the different geographic regions analyzed in one year.

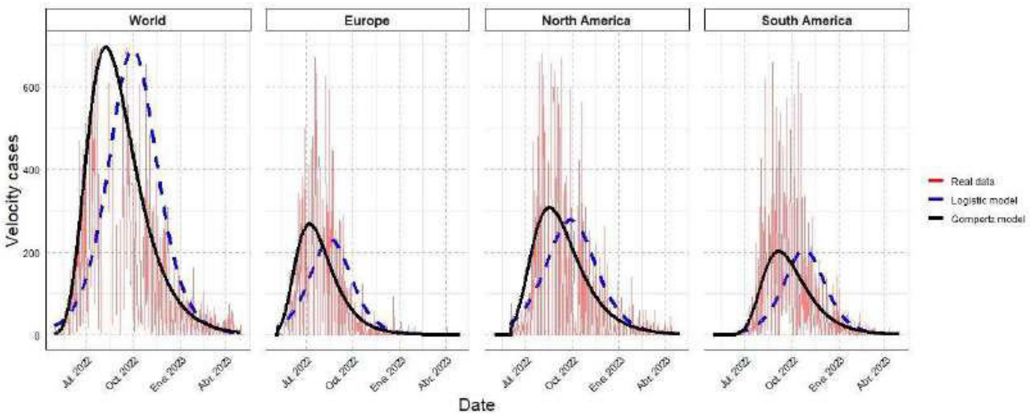
3.2. Mathematical Modeling

The mathematical models (logistic and Gompertz) were applied to each region (World, Europe, North America, and South America) independently. The results obtained are shown below (Table 1):

Table 1. Estimated parameters for the logistic and the Gompertz models.

Model	Parameters	World	Europe	North America	South America
Logistic	Coefficient of Determination R^2	0.8885	0.8720	0.9023	0.8774
Logistic	Critical time t_c (days)	152	108	117	144
Logistic	Date on t_c	30/09/2022	23/08/2022	28/09/2022	25/10/2022
Logistic	N_{max} on t_c	43,648	13,926	18,515	11,160
Logistic	Highest contagion rate (people/day)	690	230	278	206
Gompertz	Coefficient of Determination R^2	0.9952	0.9881	0.9900	0.9988
Gompertz	Critical time t_c (days)	100	62	75	94
Gompertz	Date on t_c	09/08/2022	08/07/2022	17/08/2022	05/09/2022
Gompertz	N_{max} on t_c	32,656	9,463	13,699	8,264
Gompertz	Highest contagion rate (people/day)	696	268	308	202

Finally, the results estimated by the logistic and the Gompertz models were compared with the actual data and observed simultaneously. The contagion rate of Monkeypox cases by each analyzed geographic region (Figure 2A) and the cumulative cases (Figure 2B) are shown:



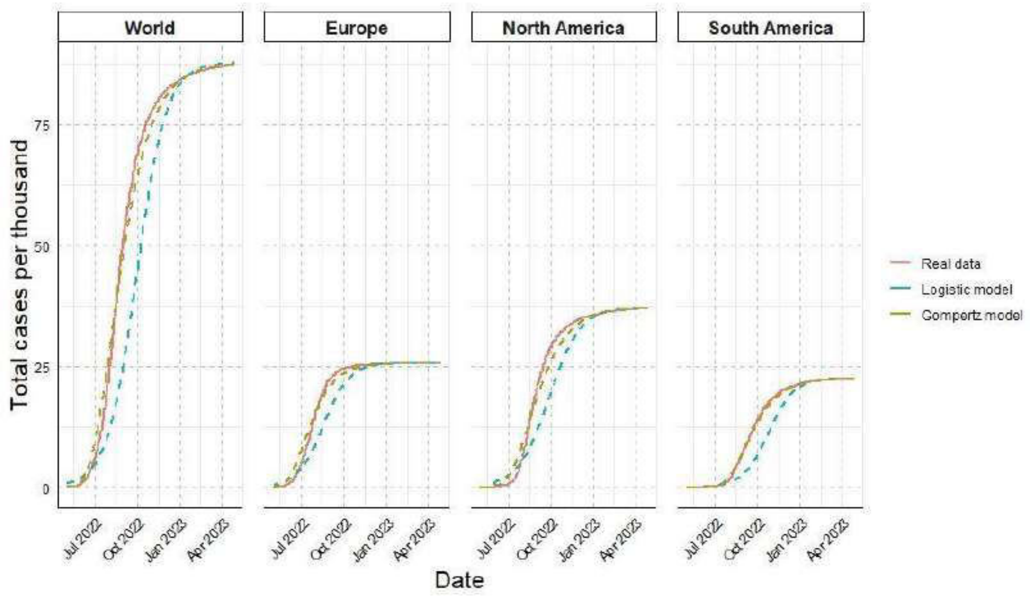


Figure 2. Epidemiological overview of Monkeypox cases for the different geographic regions analyzed in one year, comparing the actual data against the mathematical models. Top: **A)** Velocity cases. Bottom: **B)** Total cases per thousand.

3.3. Statistical Analysis

3.3.1. Normality Tests for the Variable Cases

The data from the populations (World, Europe, North America, and South America) for the modeled data did not exhibit a normal distribution. The p-value for each population (Table 2) was less than 0.05, indicating the rejection of the null hypothesis and establishing that the data does not follow a normal distribution.

Table 2. Results of the Normality Test.

Model	Geographic Region	p-value	Hypothesis testing	Interpretation
Logistic	World	6.39e-34	Reject H_0	Non-Normal Distribution
Logistic	Europe	4.11e-60	Reject H_0	Non-Normal Distribution
Logistic	North America	1.08e-32	Reject H_0	Non-Normal Distribution
Logistic	South America	1.68e-30	Reject H_0	Non-Normal Distribution
Gompertz	World	1.94e-39	Reject H_0	Non-Normal Distribution
Gompertz	Europe	3.77e-98	Reject H_0	Non-Normal Distribution
Gompertz	North America	5.37e-39	Reject H_0	Non-Normal Distribution
Gompertz	South America	2.87e-36	Reject H_0	Non-Normal Distribution

3.3.2. Kruskal-Wallis Test for Monkeypox Cases Velocity

The Kruskal-Wallis mean comparison test was conducted to assess whether there are significant differences in the monkeypox case velocities among each geographic region for the logistic and Gompertz models. The obtained p-values were 1.55e-41 and 2.71e-42, respectively, rejecting the null hypothesis and indicating that at least one population whose mean significantly differs from the means of the other populations under study for the logistic model and the Gompertz model.

3.3.3. Post-Hoc Test: Pairwise Wilcoxon Test for Monkeypox Cases Velocity

The post hoc test, the Wilcoxon pairwise test, was performed to evaluate which mean or means present significant differences compared to the other populations for both the logistic and Gompertz models. The obtained p-values (Table 3) were mostly less than 0.05, rejecting the null hypothesis and indicating significant differences among the following populations: World and Europe, World and North America, World and South America, Europe and North America, North America, and South America for both the logistic model and the Gompertz model. However, the population of Europe and South America has a p-value of 0.894 for the logistic model and 0.546 for the Gompertz model, which is greater than 0.05, hence accepting the null hypothesis and indicating that there are no significant differences between the means of both populations for both models.

Table 3. Results of the post hoc test, Wilcoxon pairwise test.

Model	Geographic Region	World	Europe	North America
Logistic	**Europe**	3.71e-30	-	-
Logistic	**North America**	3.92e-15	8.65e-06	-
Logistic	**South America**	6.23e-32	0.894	1.73e-06
Gompertz	**Europe**	3.48e-32	-	-
Gompertz	**North America**	1.71e-15	2.93e-06	-
Gompertz	**South America**	5.17e-31	0.546	5.15e-06

3.3.4. Multiple Linear Regression Analysis for Monkeypox Cases Velocity

The multiple linear regression test was conducted to determine and validate whether geographic region affects the Monkeypox case velocity for both the logistic and Gompertz models. The obtained p-values for each geographic region (Table 4) were less than 0.05, rejecting the null hypothesis and indicating that there is an effect of geographic region on the Monkeypox case velocity, supporting the results obtained in the Kruskal-Wallis and Wilcoxon tests.

Table 4. Results of the multiple linear regression analysis for monkeypox cases velocity.

Model	Geographic Region	p-value	Hypothesis testing	Interpretation
Logistic	World	$< 2.2 \times 10^{-16}$	Reject H_0	Significant effect
Logistic	Europe	0.001295	Reject H_0	Significant effect
Logistic	North America	0.000108	Reject H_0	Significant effect
Logistic	South America	9.74e-07	Reject H_0	Significant effect
Gompertz	World	$< 2.2 \times 10^{-16}$	Reject H_0	Significant effect
Gompertz	Europe	0.000314	Reject H_0	Significant effect
Gompertz	North America	$< 2.2 \times 10^{-16}$	Reject H_0	Significant effect
Gompertz	South America	$< 2.2 \times 10^{-16}$	Reject H_0	Significant effect

3.3.5. Comparison of Modeled Variable against Real Data

The comparison of actual data with the data obtained from the mathematical model for the Monkeypox case velocity by geographic region resulted in determination coefficients (R^2) for both the logistic model and the Gompertz model (Table 6):

These values indicate that both mathematical models firmly represent the actual data for all variables. However, it is essential to emphasize that the Gompertz model would be the best because the coefficients obtained are more significant than the logistic model and close to 1. In particular, the Gompertz model applied to South America showed the highest value among all (0.9988).

The adjustment analyses' results by calculating the coefficient of determination and the Akaike information criterion (A.I.C.) are also shown in the Table 6:

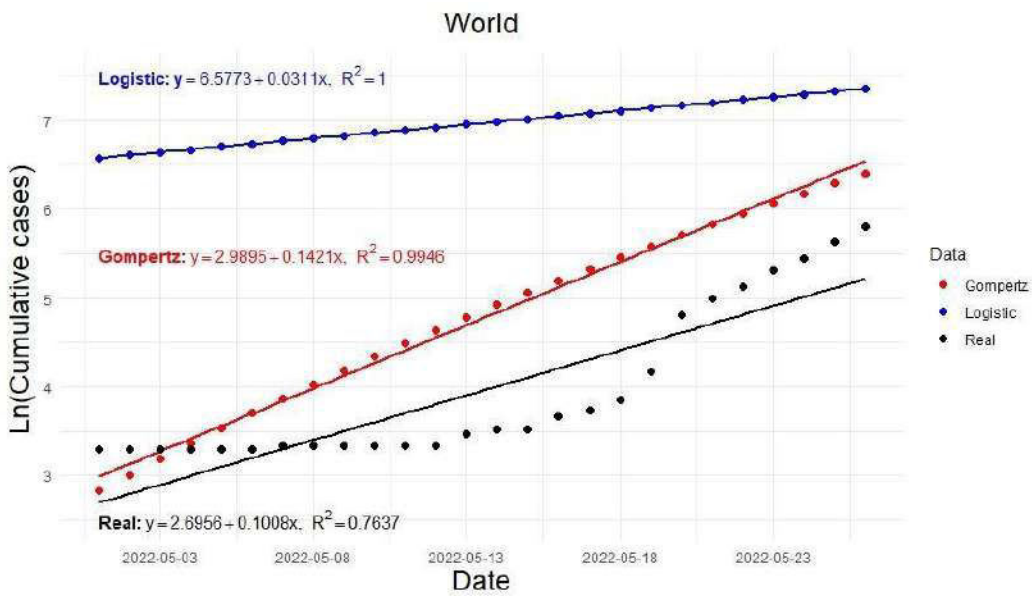
Table 6. Adjustment values for models and actual data for each region studied.

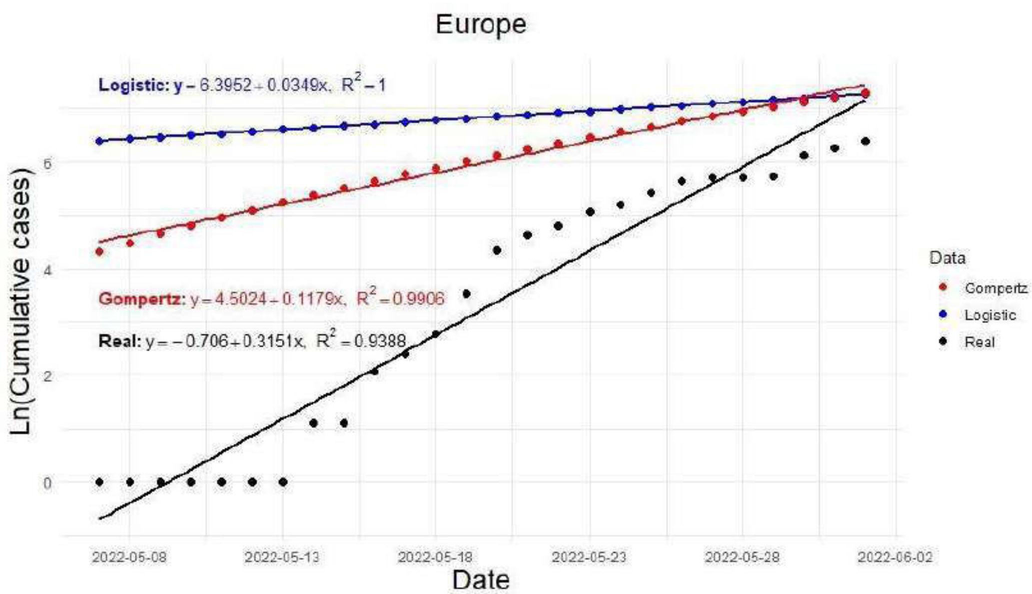
Geographic Region	R^2 – Logistic	R^2 – Gompertz	A.I.C. – Logistic	A.I.C. – Gompertz
World	0.8885	0.9952	6,836.8260	5,669.1384
Europe	0.8720	0.9881	5,783.6794	5,066.7892
North America	0.9023	0.9900	6,087.4334	5,336.7998
South America	0.8774	0.9988	5,869.6060	4,229.3746

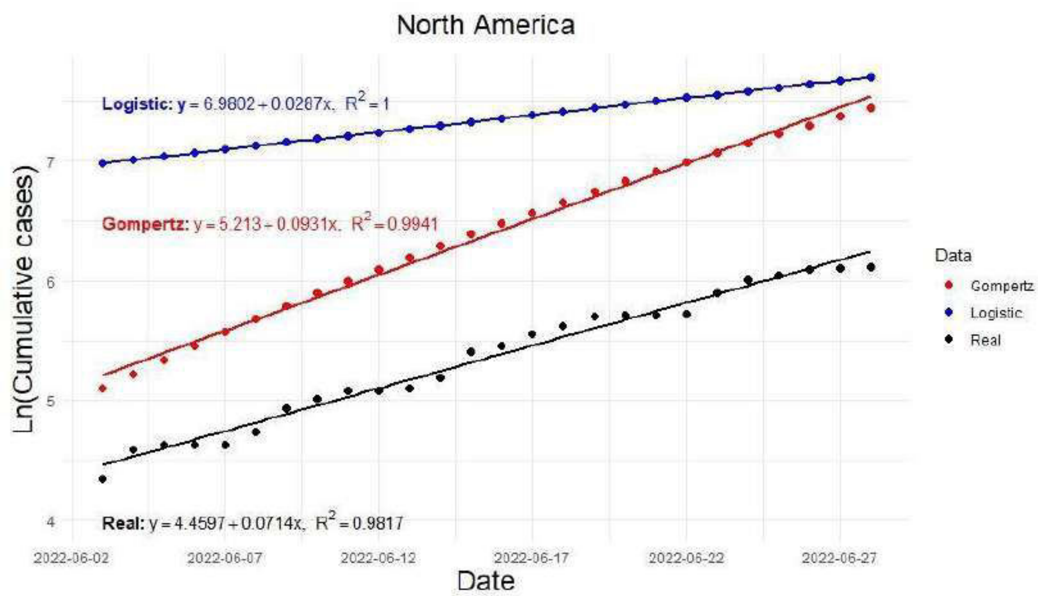
The higher coefficient of determination and the lower value of the A.I.C. index for the Gompertz model indicate a better fit to our data than the logistic model.

3.4. Estimation of the Basic Reproduction Number

Graphically, it was possible to estimate the growth rates of the epidemic for each model in each region ($r_{logistic}$, $r_{gompertz}$). The estimated regression lines are shown in Figure 3. The growth values of the epidemic are considered as the slopes of the regression lines in each case, for example, for the World: $r_{logistic} = 0.0311$ and $r_{gompertz} = 0.1421$.







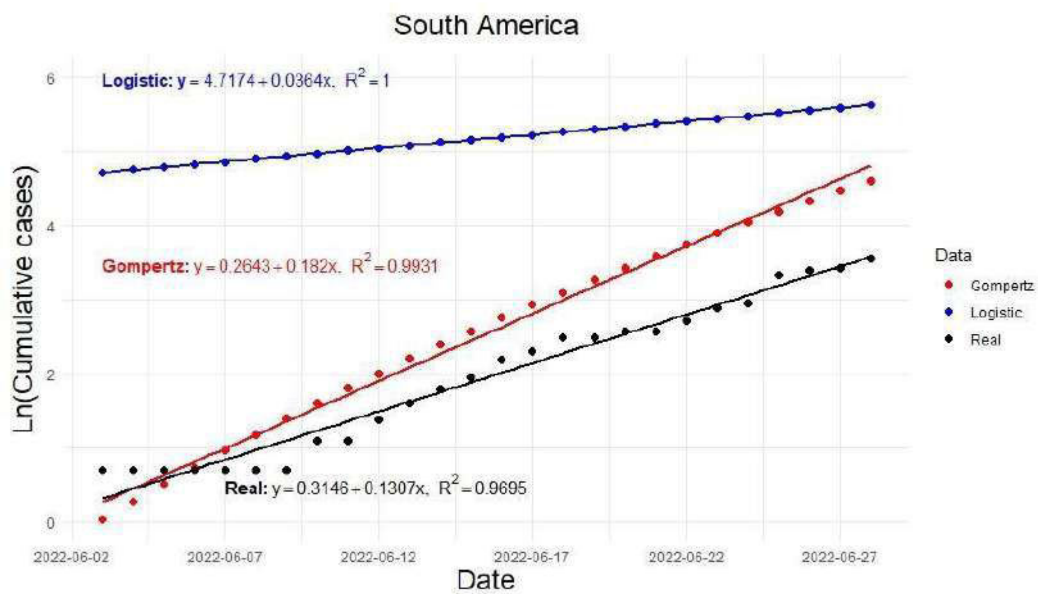


Figure 3. Linear regression curves of the actual and modeled data considering 26 days of exponential growth and taking the natural logarithm of the accumulated data for the infected population shown from top to bottom for **A)** World, **B)** Europe, **C)** North America, **D)** South America.

While the analytical approach also found values of ($r_{logistic} = k$, $r_{gompertz} = \gamma \cdot ln(\alpha)$), these are shown in Table 7:

Table 7. Growth epidemic values are determined by each region by graphical and analytical approximation.

Geographic Region	Graphical $r_{logistic}$	Graphical $r_{gompertz}$	Analytical $r_{logistic}$	Analytical $r_{gompertz}$
World	0.0311	0.1421	0.0315	0.2458
Europe	0.0349	0.1179	0.0362	0.2893
North America	0.0287	0.0931	0.0300	0.2377
South America	0.0364	0.1820	0.0367	0.2454

The calculations for R_0 assumed that the pre-infectious period is the average incubation period $D' = 9.1$ days, while the infectious period is the mean generation period $D = 12.5$ days [37]. For example, to calculate R_0 by the World with the $r\_logistic$ obtained by the graphical method: $R_0 = (1 + 0.0311 \times 9.1) \times (1 + 0.0311 \times 12.5) = 1.78178$. The estimated R_0 values using both methodologies are shown in Table 8.

Table 8. R_0 values are determined by each region by graphical and analytical approximation.

Geographic Region	Graphical Logistic $\mathcal{R}_0$	Graphical Gompertz $\mathcal{R}_0$	Analytical Logistic $\mathcal{R}_0$	Analytical Gompertz $\mathcal{R}_0$
World	1.78178	6.36625	1.79327	13.18179
Europe	1.89239	5.12781	1.93098	16.76913
North America	1.71361	3.99690	1.75038	12.56134
South America	1.93695	8.69906	1.94593	13.15080

4. Discussion

This study was conducted one year after the HMPX epidemic outbreak in different geographic regions, and through comparative mathematical modeling, the epidemiological dynamics of cases were assessed.

Poxviruses are pathogens closely linked to the history of humanity [38, 39]. Despite evolving slowly due to their sizeable double-stranded D.N.A. genome, poxviruses are highly adaptable and can undergo genotypic and phenotypic alterations to adapt and thrive in new hosts [40–42]. Furthermore, their genomic architecture can shape their evolution and sometimes interact with other viruses [41, 43].

The HMPX outbreak presents some peculiar and intriguing features in the field of virus epidemiology. First and foremost, it is an epidemic occurring within an ongoing pandemic (COVID-19) caused by the SARS-CoV-2 virus [44, 45]. Secondly, despite its primary association with primates, it can infect various animal and human species [2]. Unlike the outbreaks in humans in past decades [4], the 2022 epidemic outbreak constitutes the first significant case of global dispersion, affecting several countries and continents [5]. Third, the global discontinuation of vaccination programs against orthopoxviruses (i.e., vaccinia virus vaccine) after the eradication of smallpox potentially correlates with the re-emergence of this virus [7], implying the need to review global vaccination strategies to prevent or control new outbreaks of HMPX.

Mathematical models play a pivotal role in the anticipatory analysis of the propagation of infectious diseases, providing a crucial foundation of information for decision-makers in public health and government policy. In the present study, in addition to addressing different data, scales, and geographical spaces, we aimed to include comparative approaches and novel methodologies. While many epidemiological studies have developed compartmental mathematical models to understand the infectious dynamics of HMPX [20–23,46], there are not many studies that have attempted to explain the dynamics using a single differential equation for the infected population in HMPX. In this sense, our study provides a primary approximation model of HMPX with two large and well-studied mathematical models, namely the Logistic and Gompertz models. These models have proven to be useful in describing infectious dynamics in many cases [18,19]. Furthermore, we implemented the methodology presented by Bronshtein & Semendiaev [30] in the case of fitting the data using three points for the Gompertz model. Additionally, we calculated R_0 using an empirical and analytical approach with real data in models based on a single ordinary differential equation.

Performing mathematical modeling of HMPX cases using two models simultaneously allows us to establish comparisons to determine the one with the best fit. Thus, based on the coefficient of determination values, the Gompertz model fits our data better than the logistic model. This is because, in the daily data (velocity of cases), a slightly asymmetrical distribution is observed, with the highest rates of contagion occurring at the beginning of the epidemic. Geometrically, this represents that the tipping point (maximum speed, corresponding to the maximum number of daily recorded infections in the data) occurs before the midpoint of the accumulated infection curve.

This characteristic and better adjustment in data with these features have been determined in several epidemiological studies, where models based on differential equations are also compared [18,19]. Although there are equivalent ways of writing the Gompertz function with three parameters, it is recommended to use the form where the time coordinate is explicitly presented at the inflection point t_c [14,24]. The methodology used in this study enables us to estimate the critical time t_c based on the presented function. It also allows us to highlight the relationship between the rates of the epidemic spread r (infection rate, epidemic growth rate, or population growth rate of infected in each region), the maximum cumulative amount α, and the initial number of infected N_0 concerning the parameters of the Gompertz curve. We determined that $\beta = ln\,(\frac{\alpha}{N_0})$ and $\gamma = \frac{r}{\ln(\alpha)}$. In the case of β, this parameter controls the speed with which, given an initial amount of accumulated infected, these approach their maximum accumulated amount. The more significant the difference between α and N_0, the faster the population of infected will grow. This is deduced by taking the limit in equation (7): $\lim_{\beta\to\infty} N(t) = \lim_{\beta\to\infty} \alpha e^{-\beta e^{-\gamma t}} = 0$. Therefore, in equation (5): $\gamma \cdot N \cdot ln\,(\frac{\alpha}{N}) \to 0$ when $N \to \alpha$. On the other hand, for γ, we can calculate the intrinsic growth rate for the infected population as $r = \gamma l\,n(\alpha)$. Finally, we can calculate R_0, one of the most relevant parameters in viral epidemiology.

In the Gompertz model, taking the logarithm of the equation results in a nonlinear equation on the logarithmic scale, given the presence of the natural logarithm function $ln(\alpha/N)$. Consequently, the relationship between the slope of the linear regression and $r_{gompertz}$ is not direct. It cannot be immediately obtained through the slope of the regression line on the logarithmic scale. In contrast, when we take the logarithm of the logistic model equation, a linear relationship emerges on the logarithmic scale. This allows the slope of the linear regression to directly provide an estimate of the intrinsic growth rate ($r_{logistic}$). We also observe discrepancies when determining $r_{gompertz}$ through the two methodologies. These discrepancies arise from the Gompertz function's mathematical structure, which does not allow the determination of the growth rate through a single logarithm. Additionally, this value (the slope of the regression lines) is sensitive to the assumed amount of data as exponential growth. As a result of the above, significant discrepancies in the R_0 values, estimated by the Gompertz model, are noted in each method used to find $r_{gompertz}$. It is essential to mention that, in any case, the R_0 calculated from the Gompertz model is greater than that calculated by the logistic model. At the beginning of an outbreak, there is always a lack of data because the disease is unknown. The Gompertz model, being asymmetric, rises more quickly, leading to an R_0 that is always higher than the logistic model. However, these R_0 estimates should be viewed as initial and imprecise empirical references. They depend on factors such as periods of pre-infections, infections, and the method of calculating the rate of outbreak growth, which may vary significantly in each region and study population. Additionally, the values of the periods of infectious and pre-infectious (incubation) used for our calculations represent only average values within a wide range. Different ranges of values can be found in the literature [37,46,47].

For the logistic model, we note that when estimating $r_{logistic}$ with a small population Q compared to its carrying capacity M, its growth resembles exponential growth, and the growth rate is approximately constant. However, as the population approaches carrying capacity (Q approaches M), growth slows and approaches zero, known as the self-regulation effect of carrying capacity. Therefore, the logistic equation captures both the initial exponential growth and the eventual stabilization of the population as it approaches M.

However, it is imperative to recognize the inherent limitations of logistic models, as they assume a uniform population and equivalent vulnerability to infection.

Both methods of estimating $r_{gompertz}$ are valid only for small values of N and for an initial growth phase. As the population grows and approaches carrying capacity (α), the behavior of the Gompertz equation differs significantly from exponential growth. Therefore, this approach adequately describes the initial behavior but does not represent the complete behavior of the Gompertz model.

Due to the methodologies used, the values of R_0 should be taken as illustrative and are presented to show quantitatively that $R_0 > 1$, in any case, and the epidemic outbreak, in general, occurs faster according to the Gompertz model, which fits better with the observed data in Figure 3. Here, we note that the slopes found are closer to those found in the actual data. However, the logistic model estimated consistent values of R_0 (through graphical and analytical approximations), and they were closer to those observed at the beginning of the epidemic [48].

Even though the differences mentioned above between the two models impacted early (and better-adjusted) estimates of t_c and the highest contagion rate for the Gompertz model, both models validly approximated the epidemiological behavior of HMPX, and geographic region affects its contagion velocity. This allowed us to observe significant differences in monkeypox case velocities among each geographic region in both models, except for the peer evaluation between Europe and South America, which exhibited similar behaviors (a flatter curve) compared to North America and the World, which presented more accentuated curves. All these mathematical estimates with an epidemiological relationship enable us to understand better the dynamics of HMPX and its potential preventive and clinical implications.

Historically, Monkeypox was a self-limiting disease. However, the recent outbreak has indicated a shift in its transmission patterns, especially among men who have sex with men (MSM) [45]. Clinical manifestations have evolved, with patients now exhibiting unusual symptoms such as proctitis, tonsillitis, and paraphimosis related to penile edema [49]. Amidst this health crisis, there is a silver lining in the antigenic similarity between the smallpox virus and the monkeypox virus, allowing for smallpox vaccines as a preventive measure against Monkeypox [50].

Strategies for managing and preventing Monkeypox are based on measures initially designed for smallpox protection. Smallpox is the only infectious disease that humanity has successfully eradicated, and the strategies employed could be applied to monkeypox [51]. However, the challenge lies in understanding the monkeypox virus and its transmission patterns and developing effective treatment and prevention strategies [52].

The recent monkeypox epidemic has highlighted the virus's adeptness at evading the host's immune system. The virus has developed strategies to control the activation of antiviral T cells and the production of inflammatory cytokines. This immune evasion mechanism is crucial for the virus's efficient spread within the infected host [53]. Like other poxviruses, the monkeypox virus has evolved multiple mechanisms to evade the host's immune system [54]. The discontinuation of smallpox vaccination, which provides cross-protection against Monkeypox, may have significantly contributed to the 2022 outbreak [7]. A study on the Jynneos vaccine and monkeypox infection delves into the immune responses elicited, presenting fewer side effects than earlier smallpox vaccines [55]. It represents an example of potential improvements in vaccination strategies against HMPX and highlights the need to review current immunization programs.

With respect to the aforementioned, the models used in the present study can consider the vaccination factor as a coefficient derived from the empirical efficacy values of a potential authorized vaccine against HMPX, or they can be used to simulate various vaccine scenarios. Alternatively, the vaccination factor could be simulated by implementing fractional order or compartmentalized models, as has been published for other viral diseases [56–58]. The Logistic model suits better the initial and mid-stages of an epidemic, offering a symmetrical S-shaped curve that depicts consistent viral spread and carrying capacity.

In contrast, the Gompertz model excels in later stages, capturing slowed disease spread with its asymmetrical S-shaped curve influenced by factors like immunity. Consequently, it can be deduced that the model choice depends on the epidemic phase, disease spread nature, and data fit. Both models share a sigmoid and bounded function, but the Logistic model's tipping point creates a symmetric curve, while the Gompertz model's inflection point leads to asymmetry. Model selection hinges on observed data characteristics, considering the Gompertz model's potential initial growth rate overestimation.

5. Conclusions

The present study demonstrates that the use of mathematical models based on single differential equations firmly represents the real data, as shown by the determination coefficients (R^2) for both the logistic model and the Gompertz model. Consequently, this allows for estimating important epidemiological values such as t_c, the contagion rate, and the basic reproduction number (R_0).

The case data in the selected geographic regions showed a non-normal distribution and a significant effect of the geographic region on Monkeypox case velocity. Furthermore, significant differences were observed between case rates in these regions, except for Europe and South America, which exhibited flatter curves.

Finally, due to the nature and symmetry (or asymmetry) of the compared models, it was observed that the Gompertz model better represented the real case data, while the logistic model allowed estimating consistent values of R_0 (through graphical and analytical approximations), which were closer to those observed at the beginning of the epidemic.

Supplementary Materials: The following supporting information can be downloaded at www.mdpi.com/xxx/s1, Figure S1: title; Table S1: Real and modeled data on cases of HMPX in the assessed geographical regions.

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References

1. Shchelkunov, S.N.; Totmenin, A.V.; Safronov, P.F.; Mikheev, M.V.; Gutorov, V.V.; Ryazankina, O.I.; Petrov, N.A.; Babkin, I.V.; Uvarova, E.A.; Sandakhchiev, L.S.; et al. Analysis of the Monkeypox Virus Genome. *Virology* **2002**, 297, 172–194, doi:10.1006/viro.2002.1446.
2. Silva, N.I.O.; de Oliveira, J.S.; Kroon, E.G.; Trindade, G. de S.; Drumond, B.P. Here, There, and Everywhere: The Wide Host Range and Geographic Distribution of Zoonotic Orthopoxviruses. *Viruses* **2020**, 13, 43, doi:10.3390/v13010043.
3. Ferdous, J.; Barek, M.A.; Hossen, M.S.; Bhowmik, K.K.; Islam, M.S. A Review on Monkeypox Virus Outbreak: New Challenge for World. *Health Sci Rep* **2023**, 6, e1007, doi:10.1002/hsr2.1007.
4. Marraha, F.; Al Faker, I.; Chahoub, H.; Benyamna, Y.; Rahmani, N.; Gallouj, S. Monkeypox 2022 Outbreak: How Alarming Is the Situation? Epidemiological and Clinical Review. *Clin Pract* **2023**, 13, 102–115, doi:10.3390/clinpract13010010.
5. Niu, L.; Liang, D.; Ling, Q.; Zhang, J.; Li, Z.; Zhang, D.; Xia, P.; Zhu, Z.; Lin, J.; Shi, A.; et al. Insights into Monkeypox Pathophysiology, Global Prevalence, Clinical Manifestation and Treatments. *Front Immunol* **2023**, 14, 1132250, doi:10.3389/fimmu.2023.1132250.
6. Cheema, A.Y.; Ogedegbe, O.J.; Munir, M.; Alugba, G.; Ojo, T.K. Monkeypox: A Review of Clinical Features, Diagnosis, and Treatment. *Cureus* **2022**, 14, e26756, doi:10.7759/cureus.26756.
7. Bethineedi, L.D.; Kutikuppala, L.V.S.; Kandi, V. Monkeypox Epidemic: A Throwback From Smallpox Eradication. *Cureus* **2022**, 14, e26577, doi:10.7759/cureus.26577.
8. Qudus, M.S.; Cui, X.; Tian, M.; Afaq, U.; Sajid, M.; Qureshi, S.; Liu, S.; Ma, J.; Wang, G.; Faraz, M.; et al. The Prospective Outcome of the Monkeypox Outbreak in 2022 and Characterization of Monkeypox Disease Immunobiology. *Front Cell Infect Microbiol* **2023**, 13, 1196699, doi:10.3389/fcimb.2023.1196699.
9. Lansiaux, E.; Jain, N.; Laivacuma, S.; Reinis, A. The Virology of Human Monkeypox Virus (hMPXV): A Brief Overview. *Virus Res* **2022**, 322, 198932, doi:10.1016/j.virusres.2022.198932.
10. Adekola, H.A.; Adekunle, I.A.; Egberongbe, H.O.; Onitilo, S.A.; Abdullahi, I.N. Mathematical Modeling for Infectious Viral Disease: The COVID-19 Perspective. *J Public Aff* **2020**, 20, e2306, doi:10.1002/pa.2306.
11. Josephus, B.O.; Nawir, A.H.; Wijaya, E.; Moniaga, J.V.; Ohyver, M. Predict Mortality in Patients Infected with COVID-19 Virus Based on Observed Characteristics of the Patient Using Logistic Regression. *Procedia Comput Sci* **2021**, 179, 871–877, doi:10.1016/j.procs.2021.01.076.
12. Nopour, R.; Shanbehzadeh, M.; Kazemi-Arpanahi, H. Using Logistic Regression to Develop a Diagnostic Model for COVID-19: A Single-Center Study. *J Educ Health Promot* **2022**, 11, 153, doi:10.4103/jehp.jehp_1017_21.
13. Marín-Machuca, O.; Chacón, R.D.; Alvarez-Lovera, N.; Pesantes-Grados, P.; Pérez-Timaná, L.; Marín-Sánchez, O. Mathematical Modeling of COVID-19 Cases and Deaths and the Impact of Vaccinations during Three Years of the Pandemic in Peru. Vaccines 2023, 11, 1648, doi:10.3390/vaccines11111648.
14. Tjørve, K.M.C.; Tjørve, E. The Use of Gompertz Models in Growth Analyses, and New Gompertz-Model Approach: An Addition to the Unified-Richards Family. *PLoS One* **2017**, 12, e0178691, doi:10.1371/journal.pone.0178691.
15. Vaidya, V.G.; Alexandro, F.J. Evaluation of Some Mathematical Models for Tumor Growth. *Int J Biomed Comput* **1982**, 13, 19–36, doi:10.1016/0020-7101(82)90048-4.
16. Gerlee, P. The Model Muddle: In Search of Tumor Growth Laws. *Cancer Res* **2013**, 73, 2407–2411, doi:10.1158/0008-5472.CAN-12-4355.
17. Kozusko, F.; Bajzer, Z. Combining Gompertzian Growth and Cell Population Dynamics. *Math Biosci* **2003**, 185, 153–167, doi:10.1016/s0025-5564(03)00094-4.
18. Alharbi, Y.; Alqahtani, A.; Albalawi, O.; Bakouri, M. Epidemiological Modeling of COVID-19 in Saudi Arabia: Spread Projection, Awareness, and Impact of Treatment. *Applied Sciences* **2020**, 10, 5895, doi:10.3390/app10175895.
19. Ahmadi, A.; Fadaei, Y.; Shirani, M.; Rahmani, F. Modeling and Forecasting Trend of COVID-19 Epidemic in Iran until May 13, 2020. *Med J Islam Repub Iran* **2020**, 34, 27, doi:10.34171/mjiri.34.27.
20. Peter, O.J.; Kumar, S.; Kumari, N.; Oguntolu, F.A.; Oshinubi, K.; Musa, R. Transmission Dynamics of Monkeypox Virus: A Mathematical Modelling Approach. *Model Earth Syst Environ* **2022**, 8, 3423–3434, doi:10.1007/s40808-021-01313-2.
21. Usman, S.; Adamu, I.I. Modeling the Transmission Dynamics of the Monkeypox Virus Infection with Treatment and Vaccination Interventions. *Journal of Applied Mathematics and Physics* **2017**, 5, 2335–2353, doi:10.4236/jamp.2017.512191.
22. Ngungu, M.; Addai, E.; Adeniji, A.; Adam, U.M.; Oshinubi, K. Mathematical Epidemiological Modeling, and Analysis of Monkeypox Dynamism with Non-Pharmaceutical Intervention Using Real Data from United Kingdom. *Front Public Health* **2023**, 11, 1101436, doi:10.3389/fpubh.2023.1101436.
23. Okyere, S.; Ackora-Prah, J. Modeling and Analysis of Monkeypox Disease Using Fractional Derivatives. *Results Eng* **2023**, 17, 100786, doi:10.1016/j.rineng.2022.100786.
24. Ohnishi, A.; Namekawa, Y.; Fukui, T. Universality in COVID-19 Spread in View of the Gompertz Function. *Progress of Theoretical and Experimental Physics* **2020**, 2020, 123J01, doi:10.1093/ptep/ptaa148.
25. Pelinovsky, E.; Kokoulina, M.; Epifanova, A.; Kurkin, A.; Kurkina, O.; Tang, M.; Macau, E.; Kirillin, M. Gompertz Model in COVID-19 Spreading Simulation. *Chaos Solitons Fractals* **2022**, 154, 111699, doi:10.1016/j.chaos.2021.111699.
26. World Health Organization 2022-23 Mpox (Monkeypox) Outbreak: Global Trends Available online: https://worldhealthorg.shinyapps.io/mpx_global/ (accessed October 11, 2023).

27. Wickham, H.; Bryan, J. *R Packages: Organize, Test, Document, and Share Your Code*; Second edition.; O'Reilly: Beijing Boston Farnham Sebastopol Tokyo, 2023; ISBN 978-1-09-813494-5.
28. Kot, M. *Elements of Mathematical Ecology*; Cambridge University Press: Cambridge, 2001; ISBN 978-0-521-80213-0.
29. Bacaër, N. Verhulst and the Logistic Equation (1838). In *A Short History of Mathematical Population Dynamics*; Bacaër, N., Ed.; Springer: London, 2011; pp. 35–39 ISBN 978-0-85729-115-8.
30. Bronshtein, I.; Semendiaev, K.; Rojas, I.H. *Manual de Matemáticas Para Ingenieros y Estudiantes*; Mir, 1977; ISBN 84-8041-022-1.
31. Pereira, S.M.C.; Leslie, G. Hypothesis Testing. *Australian Critical Care* **2009**, 22, 187–191, doi:10.1016/j.aucc.2009.08.003.
32. McKight, P.E.; Najab, J. Kruskal-Wallis Test. In *The Corsini Encyclopedia of Psychology*; John Wiley & Sons, Ltd, 2010; pp. 1–1 ISBN 978-0-470-47921-6.
33. Elliott, A.C.; Woodward, W.A. *Statistical Analysis Quick Reference Guidebook*; SAGE Publications, Inc., 2007; ISBN 978-1-4129-8594-9.
34. Baguena, J.G. *Regresión Lineal Simple*; Universitat Oberta de Catalunya, 2019;
35. Schober, P.; Boer, C.; Schwarte, L.A. Correlation Coefficients: Appropriate Use and Interpretation. *Anesth Analg* **2018**, 126, 1763–1768, doi:10.1213/ANE.0000000000002864.
36. Vynnycky, E.; White, R.G. *An Introduction to Infectious Disease Modelling*; Oxford University Press: New York, 2010; ISBN 978-0-19-856576-5.
37. Guzzetta, G.; Mammone, A.; Ferraro, F.; Caraglia, A.; Rapiti, A.; Marziano, V.; Poletti, P.; Cereda, D.; Vairo, F.; Mattei, G.; et al. Early Estimates of Monkeypox Incubation Period, Generation Time, and Reproduction Number, Italy, May-June 2022. *Emerg Infect Dis* **2022**, 28, 2078–2081, doi:10.3201/eid2810.221126.
38. Piret, J.; Boivin, G. Pandemics Throughout History. *Front Microbiol* **2020**, 11, 631736, doi:10.3389/fmicb.2020.631736.
39. Sampath, S.; Khedr, A.; Qamar, S.; Tekin, A.; Singh, R.; Green, R.; Kashyap, R. Pandemics Throughout the History. *Cureus* **13**, e18136, doi:10.7759/cureus.18136.
40. Chacón, R.D.; Astolfi-Ferreira, C.S.; Pereira, P.C.; Assayag, M.S.; Campos-Salazar, A.B.; De la Torre, D.; Sá, L.R.M. de; Almeida, S.R.Y. de; Rici, R.E.G.; Ferreira, A.J.P. Outbreaks of Avipoxvirus Clade E in Vaccinated Broiler Breeders with Exacerbated Beak Injuries and Sex Differences in Severity. *Viruses* **2022**, 14, 773, doi:10.3390/v14040773.
41. Brennan, G.; Stoian, A.M.M.; Yu, H.; Rahman, M.J.; Banerjee, S.; Stroup, J.N.; Park, C.; Tazi, L.; Rothenburg, S. Molecular Mechanisms of Poxvirus Evolution. *mBio* **2023**, 14, e0152622, doi:10.1128/mbio.01526-22.
42. Li, K.; Yuan, Y.; Jiang, L.; Liu, Y.; Liu, Y.; Zhang, L. Animal Host Range of Mpox Virus. *J Med Virol* **2023**, 95, e28513, doi:10.1002/jmv.28513.
43. Chacón, R.D.; Astolfi-Ferreira, C.S.; De la Torre, D.I.; de Sá, L.R.M.; Piantino Ferreira, A.J. An Atypical Clinicopathological Manifestation of Fowlpox Virus Associated with Reticuloendotheliosis Virus in Commercial Laying Hen Flocks in Brazil. *Transbound Emerg Dis* **2020**, 67, 2923–2935, doi:10.1111/tbed.13668.
44. Khamees, A.; Awadi, S.; Al-Shami, K.; Alkhoun, H.A.; Al-Eitan, S.F.; Alsheikh, A.M.; Saeed, A.; Al-Zoubi, R.M.; Zoubi, M.S.A. Human Monkeypox Virus in the Shadow of the COVID-19 Pandemic. *J Infect Public Health* **2023**, 16, 1149–1157, doi:10.1016/j.jiph.2023.05.013.
45. Aden, D.; Zaheer, S.; Kumar, R.; Ranga, S. Monkeypox (Mpox) Outbreak during COVID-19 Pandemic-Past and the Future. *J Med Virol* **2023**, 95, e28701, doi:10.1002/jmv.28701.
46. Liao, L.-C.; Hsu, C.-Y.; Chen, H.-H.; Lai, C.-C. Estimating the Global Spread of Epidemic Human Monkeypox with Bayesian Directed Acyclic Graphic Model. *Vaccines* **2023**, 11, 468, doi:10.3390/vaccines11020468.
47. Miura, F.; van Ewijk, C.E.; Backer, J.A.; Xiridou, M.; Franz, E.; Op de Coul, E.; Brandwagt, D.; van Cleef, B.; van Rijckevorsel, G.; Swaan, C.; et al. Estimated Incubation Period for Monkeypox Cases Confirmed in the Netherlands, May 2022. *Euro Surveill* **2022**, 27, 2200448, doi:10.2807/1560-7917.ES.2022.27.24.2200448.
48. Du, Z.; Shao, Z.; Bai, Y.; Wang, L.; Herrera-Diestra, J.L.; Fox, S.J.; Ertem, Z.; Lau, E.H.Y.; Cowling, B.J. Reproduction Number of Monkeypox in the Early Stage of the 2022 Multi-Country Outbreak. *J Travel Med* **2022**, 29, taac099, doi:10.1093/jtm/taac099.
49. Zingaropoli, M.A.; Parente, A.; Kertusha, B.; Campagna, R.; Tieghi, T.; Garattini, S.; Marocco, R.; Carraro, A.; Tortellini, E.; Guardiani, M.; et al. Longitudinal Virological and Immunological Profile in a Case of Human Monkeypox Infection. *Open Forum Infect Dis* **2022**, 9, ofac569, doi:10.1093/ofid/ofac569.
50. Ophinni, Y.; Frediansyah, A.; Sirinam, S.; Megawati, D.; Stoian, A.M.; Enitan, S.S.; Akele, R.Y.; Sah, R.; Pongpirul, K.; Abdeen, Z.; et al. Monkeypox: Immune Response, Vaccination and Preventive Efforts. *Narra J* **2022**, 2, doi:10.52225/narra.v2i3.90.
51. World Health Organization. History of Smallpox Vaccination Available online: https://www.who.int/news-room/spotlight/history-of-vaccination/history-of-smallpox-vaccination (accessed October 12, 2023).
52. Mukherjee, A.G.; Wanjari, U.R.; Kannampuzha, S.; Das, S.; Murali, R.; Namachivayam, A.; Renu, K.; Ramanathan, G.; Doss C, G.P.; Vellingiri, B.; et al. The Pathophysiological and Immunological Background of the Monkeypox Virus Infection: An Update. *J Med Virol* **2023**, 95, e28206, doi:10.1002/jmv.28206.
53. Zandi, M.; Shafaati, M.; Hosseini, F. Mechanisms of Immune Evasion of Monkeypox Virus. *Front Microbiol* **2023**, 14, 1106247, doi:10.3389/fmicb.2023.1106247.
54. Shafaati, M.; Zandi, M. Human Monkeypox (hMPXV) Re-Emergence: Host Immunity Status and Current Vaccines Landscape. *J Med Virol* **2023**, 95, e28251, doi:10.1002/jmv.28251.

55. Cohn, H.; Bloom, N.; Cai, G.Y.; Clark, J.J.; Tarke, A.; Bermúdez-González, M.C.; Altman, D.R.; Lugo, L.A.; Lobo, F.P.; Marquez, S.; et al. Mpox Vaccine and Infection-Driven Human Immune Signatures: An Immunological Analysis of an Observational Study. *Lancet Infect Dis* **2023**, S1473-3099(23)00352-3, doi:10.1016/S1473-3099(23)00352-3.
56. Faniran, T.S.; Ali, A.; Al-Hazmi, N.E.; Asamoah, J.K.K.; Nofal, T.A.; Adewole, M.O. New Variant of SARS-CoV-2 Dynamics with Imperfect Vaccine. *Complexity* **2022**, 2022, e1062180, doi:10.1155/2022/1062180.
57. Ali, A.; Ullah, S.; Khan, M.A. The Impact of Vaccination on the Modeling of COVID-19 Dynamics: A Fractional Order Model. *Nonlinear Dyn* **2022**, 110, 3921–3940, doi:10.1007/s11071-022-07798-5.
58. Xu, C.; Wang, Y.; Cheng, K.; Yang, X.; Wang, X.; Guo, S.; Liu, M.; Liu, X. A Mathematical Model to Study the Potential Hepatitis B Virus Infections and Effects of Vaccination Strategies in China. *Vaccines* **2023**, 11, 1530, doi:10.3390/vaccines11101530.

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