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AIP Conference Proceedings 2183 , 090003 (2019); https://doi.org/10.1063/1.5136203 2183 , 090003 © 2019 Author(s). The effect of social media for a Zika virus transmission with Beddington DeAngelis incidence rate: Modeling and analysis Cite as: AIP Conference Proceedings 2183 , 090003 (2019); https://doi.org/10.1063/1.5136203 Published Online: 06 December 2019 Puji Andayani TheAE? ectAofASocialAMediaAforAaAZikaAVirusATransmission withABeddingtonADeAngelisAIncidenceARate:AModelingAand Analysis PujiAAndayani UniversitasAInternasionalASemenAIndonesia,AGresik,AIndonesia puji.andayani@uisi.ac.id Abstract. ThisApaperAdiscussAaAmodi?edAmathematicalAmodelAofAZikaAvirusAtransmissionAandAanalyzesAtheAimpactAofAtheAawareness programsAonAsocialAmediaAtheAmodi?cationAofAofAZikaAVirusAmodelAwithAsaturatedAincidenceArate.ATheABeddington-DeAAngelis functionalAresponsesAusedAtoAdescribeAtheAinteractionAbetweenAaAsuspectedAhumanAandAanAinfectedAhuman.ATheAdynamicsAofAthe modelAwereAanalyzedAbyAidentifyingAtheAdisease-freeA(DFE)AandAendemicAequilibriumA(END).ANextAGenerationAMatrixA(NGM) wasAusedAtoAdetermineAtheABasicAReproductionANumber.ATheAstabilityAofADFEAandAENDAwereAanalyzedAlocallyAbyAcomputingAthe determinantAofAJacobian.ATheADFEAwasAidenti?edAasAlocallyAstableAwhenAtheAbasicAreproductionAnumberAwasAlessAthanAunity;Aand wasAidenti?edAasAunstableAotherwise.AMeanwhile,AtheAENDAwasAidenti?edAasAexistentsAwhenAtheAbasicAreproductionAnumberAwas greaterAthanAunity.ATheARouth-HurwitzACriterionAshowedAthatAtheAENDAwasAlocallyAstableAunderAaAspeci?cAcondition.AAAsensitivity analysisAwasAalsoAcomputedAtoAdetermineAtheAmostAin?uentialAparameterAvalueA ofAtheAmodel.AInAtheAend,AtheAstabilityAofADFEAand ENDAwereAalsoAidenti?edAnumericallyAdependingAonAcertainAparameterAvalues.

Keywords :
ZikaAVirus,Adynamics,AsocialAmedia,AreproductionAnumber,ANextAGenerationAMatrix ,ABeddington-DeAAngelis,Asatu- ratedAincidenceArate
PACS:A02.30.Hq,A02.60.Cb,02.70.-c INTRODUCTION

ZikaAvirusAisAmostlyAtransmitedAthroughAaAbiteAfromAanAAidesAaegyptiAmosquito AduringAtheAdayAorAnight.AZikaAisAalso spreadAthroughAaAsexualAcontactAbetweenAanAinfectedAhumanAandAanAuninfecte dAhuman.AInAsomeAcases,AZikaAisAalso passedAonAbyApregnantAwomenAtoAherAfetusAwhich,AcausesAbirthAdefect.ANoAvac cineAhasAbeenAfoundAtoApreventAZika virusA[1].ABasedAonA[2],ApreventingAZikaAcanAbeAdoneAbyAusingAinsecticide-treate dAbedAnetsAandAmosquitoArepellent usingAcondomAandAprohibitingApregnantAwomenAtoAtravelAtoAareaAwithAZikaAout breakA[1].

Recently,AmostApeopleAchangeAtheirAmodeAofAcommunicationAfromAface-to-faceAi ntoAonlineAcommunication.

SocialAmediaAisAoneAofAtheAbestAformsAofAtechnologyAthatArespondsAtoApeople’ sAneedsAtoAcommunicateAandAshare informationAonline.ASomeAcommonAsocialAmediaAareAFacebook,ATwitter,AYoutube, AWhatsapp,AandAInstagramAcanAbe accessedAeasilyAbyAusingAsmartAphonesAandAcellularAapplicationsA[3].

InAaAdisease’sAepidemiology,AsocialAmediaAhasAanAimportantAroleAtoAinformAtheA disease’sAoutbreak.ASocialAmedia andATVAadvertisingAisAoneAmethodAtoApreventAtransmission.AMisraA[4]AhasAmade AaAmathematicalAmodelAtoAseeAthe impactAofATVAadvertisingAandAsocialAmediaAonAtheAdynamicsAofAinfectiousAdisea ses.AThereAareAvulnerableApopulations thatAareAvulnerableAtoAinfectionAasAwellAasApopulationsAthatAoftenAaccessAinform ationAthroughAsocialAmedia.ATheAZika virusAtransmissionAcanAbeAinformedAthroughAsocialAmedia,AthenApeopleAcanAtake ApreventiveAmeasures.AZikaAvirus outbreakAisAexpectedAtoAbeAcontrolledAorAdoesAnotAspreadAintoAouterAterritory.A TheAmathematicalAmodelAofAsocial mediaAimpactAforAtheAepidemiologicalAdiseaseAhasAbeenAresearchedAbyAsomeAau thors.AInA2014,AtheAe ?ectsAofAmedia forAin?uenzaAepidemicAwasAdiscussedA[5].ATheASEIRAmodelAwasAconstructedAbyAi ncludingAtheAmediaAfunction.AThe function f (I , p

)AwasAdeterminedAtoAreduceAtheAtransmission.AInA2018,AaAmathematicalAmodelAofAZikaAvirusAtransmission hasAbeenAconstructedAandAdevelopedA[6]A[7].AInAthisApaper,AweAstudyAtheAimpactAofAawarenessAprogramsAonAsocialAmedia. TheAnewAparameterAm,AwhichAbecomesAtheAbasisAofAtheAexponentialAwillAbeAanalyzed.AWeAconsiderAsomeAofAtheAtrig-gerAfactorsAandApreventiveAactionsAwhichAareAexplainedAinAaAsaturatedAmodelAusingABeddingtonADeAngelisAincidentArate.

RESULT MathematicalAModel LetA(S h , I h , R h , S v , I v)AisAtheAsolutionAofAtheAsystem,AwithApositiveAinitialAvalue. N h and N v areAtheAtotalApopulationAof humanAandAmosquitoesArespectively,Awhereas N h = S h + I h + R h and N v = S v + I v .AWeAassumeAallAparameterAand variablesAareApositives.AThenAtheAsolutionAofAsystemAareAinAtheAfollowingA: _ O= (S h , I h , R h , S v , I v) ? R + 5 ; N h = ? h µ h , N v = ? v µ v _ . (1) TheAderivationArespectAtoAtimeAofAtheAtotalApopulationAofAtheAmodelAmodel1AareA: dN h dt =? h - µ h N h . TheAsolutionAof dN h dt + µ h N h =? h is ? h µ h - Ce µ h t .AIf N h = ? h µ h ,Athen ? h µ h = 0 . If N h > ? h µ h ,Athen ? h µ h < 0 .

ThenAchooseAtheAinitialAvalueAasAfollowsA: 1. N h (0) = 0,AthenAtheAsolutionAis N h (t) = ? h µ h (1 - e µ h t), 2. N h (0) = ? h µ h ,AtheAsolutionAis N h (t) = ? h µ h , 3. N h (0) > 0,AtheAsolutionAis N h (t) = ? h µ h (1 - e µ h t) + N h (0) e µ h t . TheAtotalApopulationAofAhumansAandAmosquitoesAareAinAtheAfollowingA:A0 = N h (t) = N h (t) = ? h µ h (1 - e µ h t) + N h (0) e µ h t , andA0 = N v (t) = N v (t) = ? v µ v (1 - e µ v t) + N v (0) e µ v t .

InAparticularA:AN h (t) = ? h µ h , N v (t) = ? v µ v whenAN h (0) = ? h µ h , N v (0) = ? v µ v . ThenAtheAarea _ O= (S h , I h , R h , S v , I v) ? R + 5 ; N h = ? h µ h , N v = ? v µ v _ isAbounded. MathematicalAAnalysis LetAtheArightAhandAequationAofAtheAsystemAbyAzero.ATheAequilibriumApointsAofAtheAsystemAareAdiseaseAfreeAequilibrium (DFE)AandAendemicAequilibriumA(END). TheAdiseaseAfreeAequilibriumAofAtheAsystemAis DAFAE = (N h 0 , I h 0 , R h 0 , N v 0 , I v 0) = _ ? h µ h , 0 , 0 , ? v µ v , 0 _ . (2) TheADFEAisAalwaysAexists. BasicAreproductionAratioAisArepresentAtheAnaturalAcompartmentedAforAdiseaseAtransmissionAmodel,AestablishedAby theAsystemAofAordinaryAdi? erentialAequation.AInAthisAwork,AtheAbasicAreproductionArationAcomputeAbyANGMAasAfollows.

F = ??? ? ? ??? ?? ß 1 N h 0 1 + a 1 N h 0 ß 2 N h 0 1 + a 3 N h 0 ß 3 N v 0 0 ???? ? ??? ?? , V = _ ? + µ h 0 0 µ v _ . (3) F isAtheAjacobianAofAinfectionAmatrixAwithArespectAtoADFE,Aand V theAjacobianAmatrixAwhichAdecreaseAtheAinfection. V - 1 = ??? ? ? ? ? ? ? ? ? ? ? ? 1 ? + µ h 0 0 1 µ v ??? ? ? ? ? ? ? ? ? ? ? ? , F.V - 1 = ??? ? ? ? ? ? ? ? ? ? ? ? ? ? ß 1 N h 0 (1 + a 1 N h 0)(? + µ h) ß 2 N h 0 (1 + a 3 N h 0) µ v ß 3 N v 0 (? + µ h) 0 ??? ? ? ? ? ? ? ? ? ? ? ? ? ? . (4)

Furthermore,AtheAbasicAreproductionAnumberAisAtheAlargestAnumberAofAeigenvaluesAof F. V - 1 . R 0 = R 01 + _ R 2 01 + 4 R 02 2 ;A(5) where, R 01 = ß 1 P 1 , R 02 = ß 2 ß 3 P 1 P 2 N v N h .

LemmaA1

TheAdisease-freeAequilibriumA(DFE)AofAtheAsystemAisAlocallyAasymptoticallyAstableAwhen R 0 < 1, otherwiseAitAisAunstable. TheAendemicAequilibriumAofAtheAsystemAis EANAD = (S * h , I * h , R * h , S * v , I * v) . (6) LemmaA2 TheAendemicAequilibriumA(END)AofAtheAsystemAisAexistAif R 0 > 1Aand a 1 d - (ß 1 e - mI h + a 2 µ h) > 0. TheAnumericalAresultAusedAtoAverifyAtheAmathematicalAanalysis.AForAtheApurposeAofAsimulation,AweAchooseAsome parameterAvalueAwhichAisAsatisfyAtheAquali?cationAcondition.ATheAfollowingAtableAareAprovideAtheAparameterAdescription andAtheAparameterAvalueAwhichAisAusedAinAtheAnumericalAsimulation. TheAsensitivityAanalysisAwasAperformedAtoAdetermineAtheArelativeAimportanceAofAmodelAparametersAofAdisease transmission.ALetAchooseAtheAparameterAvalue, µ v = 0 .0714 ,µ h = 0 .

00004215 , ? h = 10 , ? v = 20 ,ß 1 = 0 . 001 ,ß 2 = 0 . 02 ,ß 3 = 0 . 01 ,a 1 = 0 .8 ,a 3 = 0 .7 ,? = 0 . 1428.ABasedAonAnormalizationAsensitivityAindexAof R 0 andAmathematical computation,AweAhaveAtheAfollowingAresultA(TableA1). TABLEA1. TableAofAsensitivityAindexAforAeachAparameterAofAtheAsystem Parameter Sensitivity Index Interpretation (IncreasingAorAdecreasing)ARank ? h 0.000003021849159 ? h byA10%, R 0 byA0.00003%A6 µ h -0.00015129107 µ h byA10%, R 0 byA0.015%A5 a 1 -0.004939244191 a 1 byA10%, R 0 byA0.49%A4 a 2 0 a 2 byA10%, R 0 byA0%A7 a 3 -0.4975273692 a 3 byA10%, R 0 byA49%A3 ß 1 0.0049392702 ß 1 byA10%, R 0 byA0.49%A4 ß 2 0.4975303648 ß 2 byA10%, R 0 byA49%A3 ß 3 0.4975303648 ß 3 byA10%, R 0 byA49%A3 ? -0.5355979617 ? byA10%, R 0 byA53%A2 ? v 0.4975303648 ? v byA10%, R 0 byA49%A3 µ v -0.9950607298 µ v byA10%, R 0 byA99%A1 AccordingAtoATable.1,AweAcanAconcludeAthatAtheAreproductiveAnumberAisAmostAsensitiveAto µ v (perAcapitaArecovery rateAofAtheAinfectiveApopulation)AandAleastAsensitiveAis a 2 . CONCLUSION ToAseeAtheAe?ectsAofAsocialAmediaAonAtheAtransmissionAofAZikaAvirus,AmathematicalAmodelsAusingAsystemsAwithA?ve

nonlinearAdi?erentialAequationsAwereAconstructed.ATheAboundednessAproblemAisAa
nalyzedAbyAordinaryAmathematical
calculations,AandAitAisAprovenAthatAtheAsystemAisAbounded.ATwoAtypesAofAequilib
riumApoints,AnamelyAdisease-freeAandAen-
demicAwereAfoundAwithAcertainAexistingAconditions.ATheAbasicAreproductionAnum
bersAwereAobtainedAbyAusingAtheANext
GenerationAMatrixA(NGM),AthenAitAbecameAtheAbasisAforAtheAconditionsAofAstabili
tyAandAtheAexistenceAofAequilibrium
points.ADynamicAanalysisAhasAbeenAcarriedAoutAbyAusingAsupportingAtheoremsAsu
chAasADescartesAandARouth-Hurwitz
criteria.ABasedAonAtheAresultsAofAtheAdynamicAanalysis,AlocalAdisease-freeAequilibr
iumApointsAareAobtainedAwhenAtheAbasic
reproductionAnumberAwasAlessAthanAunity.AConversely,AendemicAequilibriumApoint
sAexistAandAlocallyAstableAwhenAtheAba-
sicAreproductionAnumberAisAmoreAthanAunityAandAcertainAparameterArequirements
AareAsatis?ed.AWeAalsoAdidAaAsensitivity
analysisAtoAseeAwhichAparametersAwereAtheAmostAin?uential.ABasedAonAtheAresult
sAofAtheAanalysis,AinAthisAmatter,AtheAmost
in?uentialAparameterAwasAtheAdeathArateAogAmosquitoesA(μ v
),AsoAtoAreduceAtheAZikaAoutbreak,AeradicatingAmosquitoesAis
essential.AThisAcanAbeAdoneAbyAfogging,AorA3AMA(b
uryingAusedAgoods,AdrainingAtubsAandApuddles,AclosingAwaterAstorage).

TheAparameterAmAplayedAanAindirectArole,AnamelyAbyAreducingAtheArateAofAtran
smissionAbetweenAsusceptibleAhumans
andAinfectedAmosquitoes.AThisAwillAbeAshownAinAtheAcaseAstudyApresentedAinAth
eAdiscussion.ANumericalAsimulationsAof
theAdynamicAbehaviorAofAequilibriumApointsAwereAalsoApresentedAtoAcomplement
AtheAanalyticalAresults.ASoAitAcanAbe
concludedAthatAsocialAmediaAhaveAanAe?ectAonAreducingAtheAspreadAofAtheAZika
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AtheAgreatestAsupport. REFERENCES
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