Foot and Mouth Disease Control Measures through Nationwide Vaccination in Republic of Korea

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OVERVIEWS OF FMD OUTBREAKS AND APPLIED VACCINES IN SOUTH KOREA

FMD outbreaks in S. Korea

❖ **FMD free country for 66 years since 1934**

❖ **9 outbreaks from 2000 to 2017.2**

FMD-free country without vaccination

1st
- Mar. 2000, 15 cases(cattle), O type (Pan Asia), Vaccination
- Aug. 2001, FMD-free country without vaccination

2nd
- May. 2002, 16 cases(cattle, pig), O type (Pan Asia)
- Nov. 2002, FMD-free country without vaccination

3rd
- Jan. 2010, 6 cases(cattle), A type(ASIA)

4th
- Apr. 2010, 11 cases(cattle, pig), O type(SEA)
- Sep. 2010, FMD-free country without vaccination

FMD-free country with vaccination

5th
- Nov. 2010, 153 cases(cattle, pig etc.), O type(SEA), Vaccination.
- May. 2014, FMD-free country with vaccination

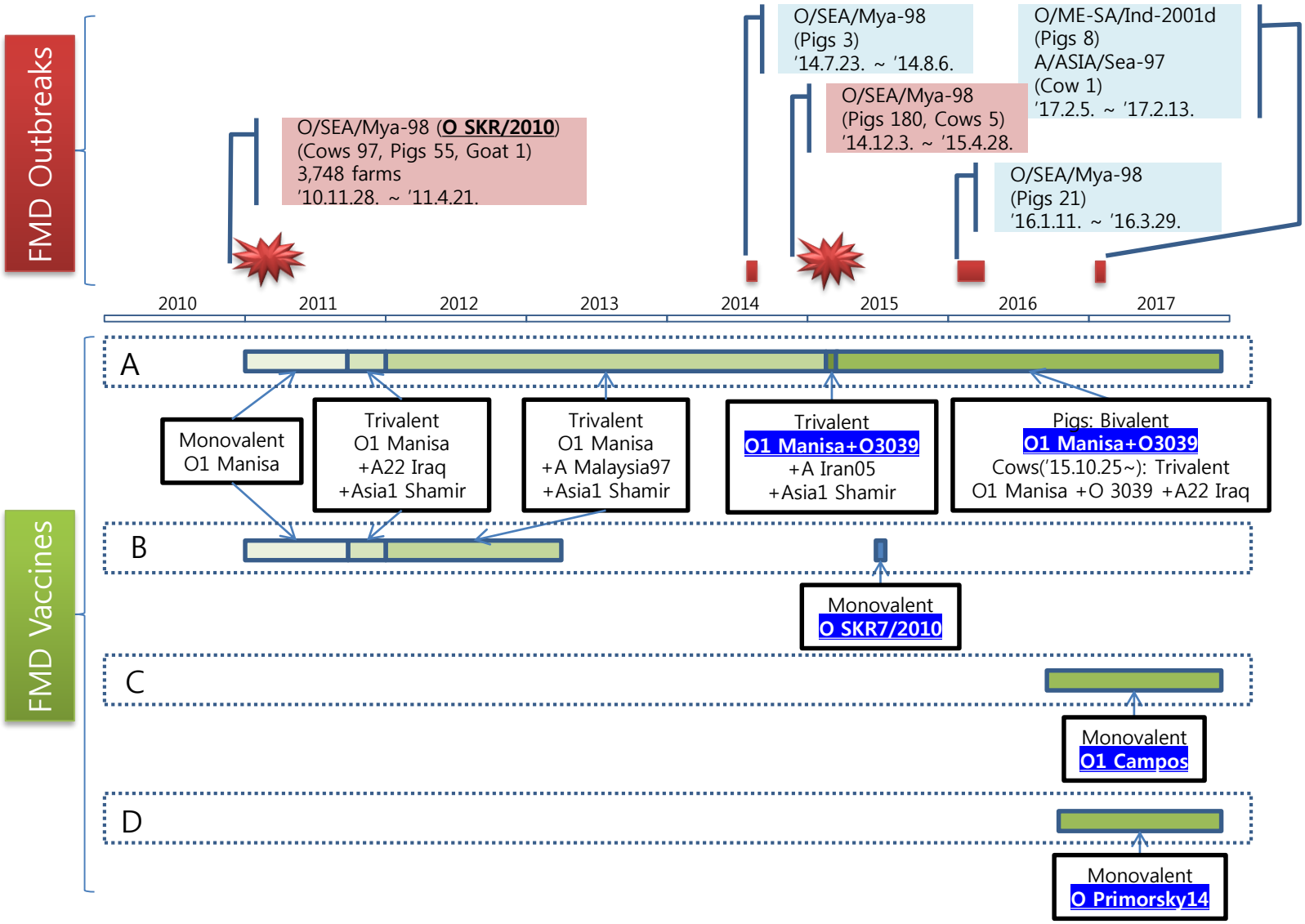
6th
- Jul. 2014, 3 cases(pig), O type(SEA)

7th
- Dec. 2014, 185 cases(cattle, pig), O type(SEA)

8th
- Jan 2016, 21 cases(pig), O type(SEA)

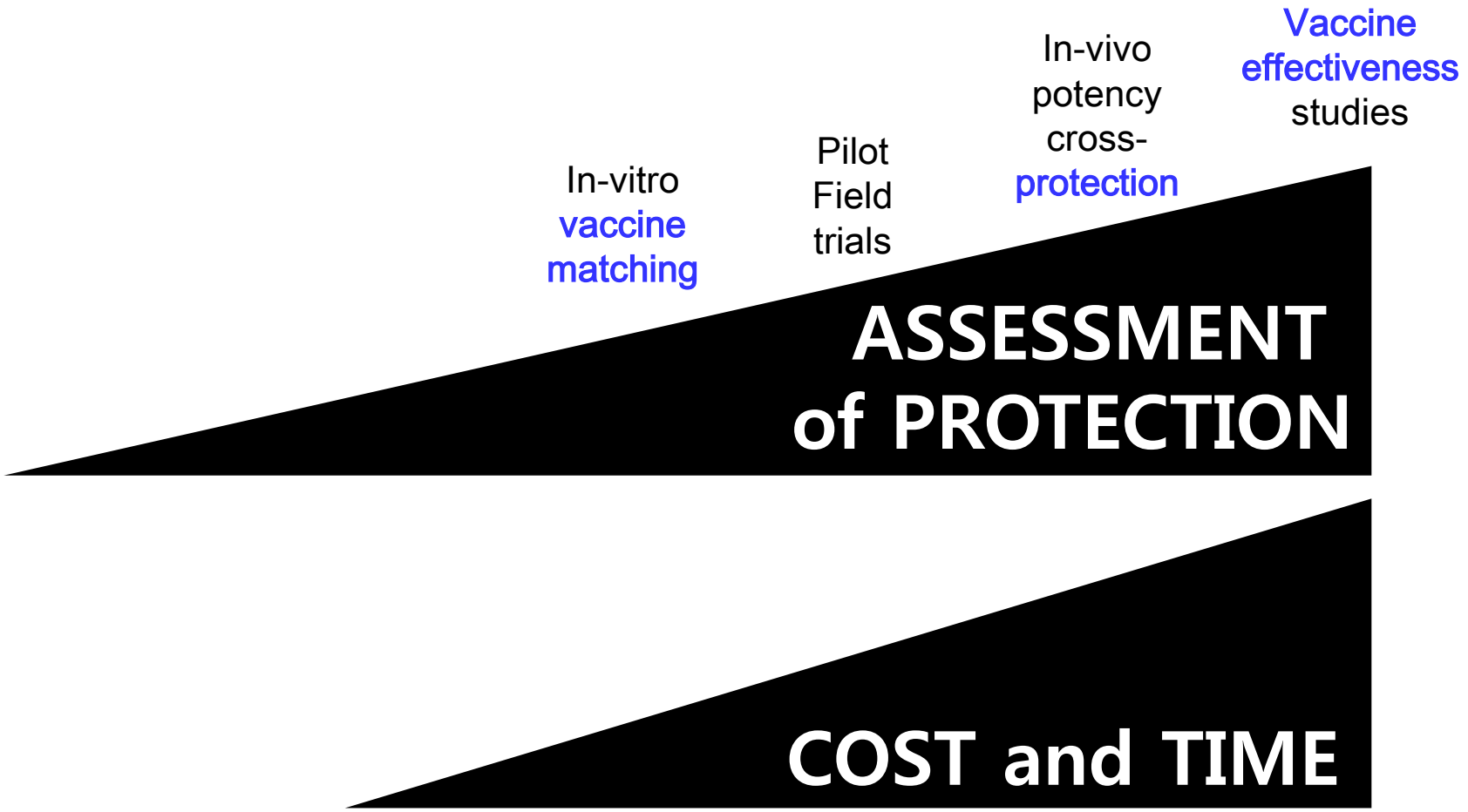
9th
- Feb 2017, 8 cases(cattle), O type(ME-SA)
- Feb 2017, 1 cases(cattle), A type(ASIA)

FMD Outbreak vs. Vaccine used in S. Korea



TESTS TO CHECK FMD VACCINE EFFICACY

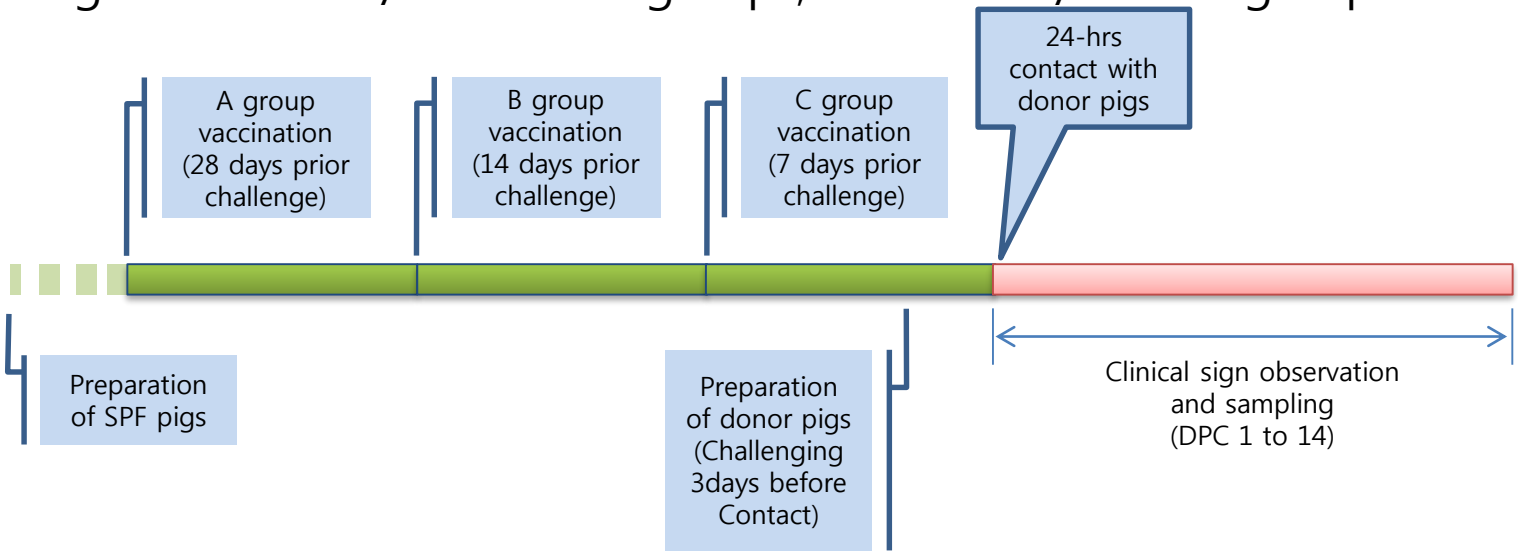
Factors for evaluation of vaccine effectiveness



From WRLFMD, Pirbright

Efficacy test of FMD vaccines in pigs

- Vaccination and challenge test (Heterologous cross-protection challenge test)
  - Evaluate the protection against O SKR/2014 (Jincheon strain, O/SEA/Mya98) after vaccination
  - A few weeks after vaccination, challenge the virus and check the clinical signs of FMD on pigs
    - Clinical signs: forming vesicles, erosion, ulcer, etc., on soft tissues, the mouth, snout, and hoofs
  - Pigs: 4~5 heads/vaccinated groups, 2~3 heads/control group



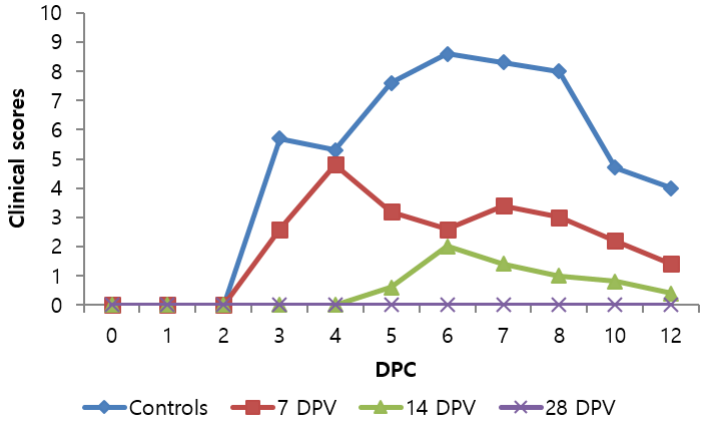
Vaccines tested for efficacy in pigs

Strain	Topotype	Lineage	Adjuvant	Comment
O1 Manisa + O 3039	ME-SA/n.a.	n.a./n.a.	n.a., W/O/W	≥ 6 PD_{50} /dose
O 3039	n.a.	n.a.	n.a., W/O/W	
O SKR 7/2010	SEA	Mya98	ISA 206, W/O/W	
O1 Campos	EURO-SA	n.a.	ISA 50 (V2+V4), W/O	
O Primorsky 14	SEA	Mya98	ISA 206 VG, W/O	
O Taiwan 97	Cathay	n.a.	ISA 70 VG, W/O	

* n.a. = not available

Efficacy of the **O1 Manisa+O 3039** vaccine after challenging with Jincheon virus(O SKR/2014) in pigs

< Clinical scores >



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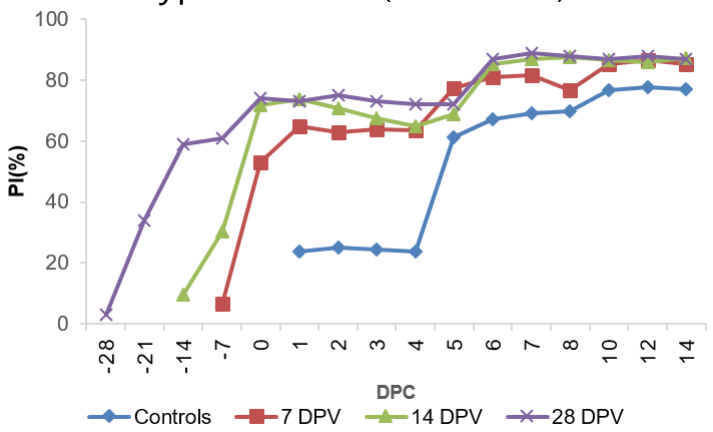

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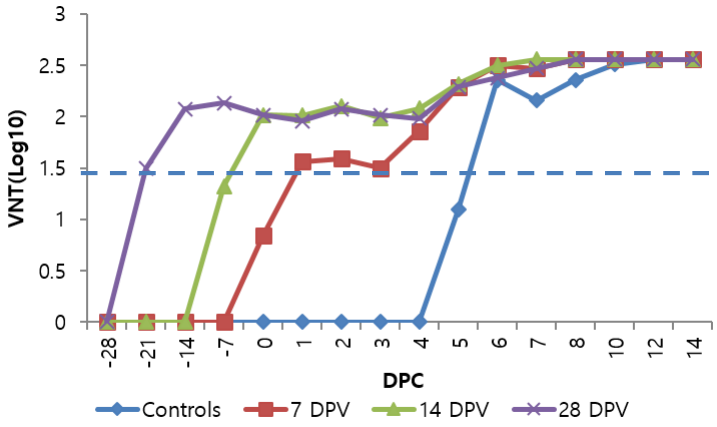

*** O1 Manisa**

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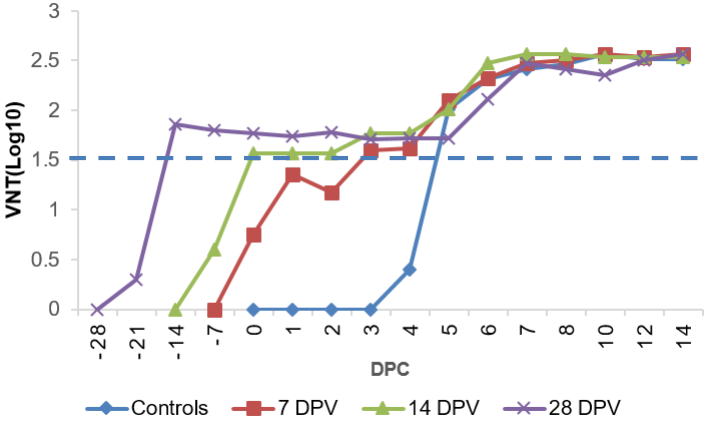
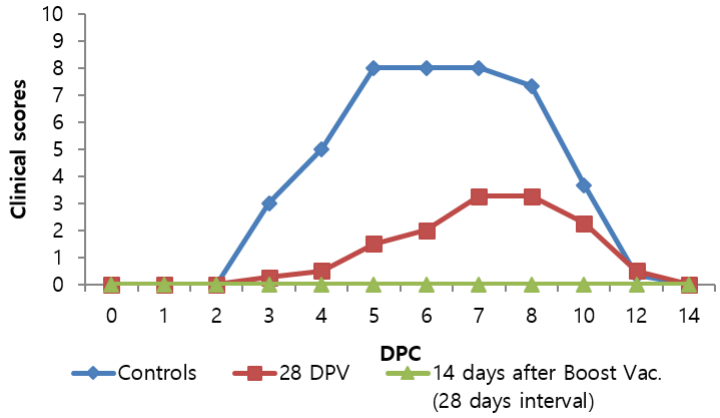


**** O SKR/2014**

Efficacy of the **O 3039** vaccine after challenging with Jincheon virus(O SKR/2014) in pigs

< Clinical scores >



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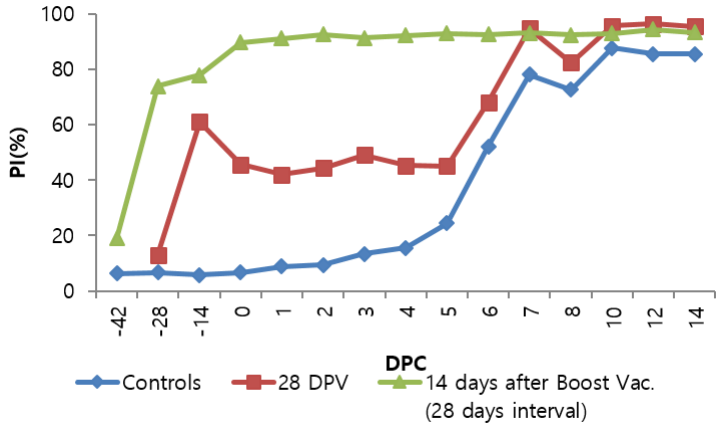

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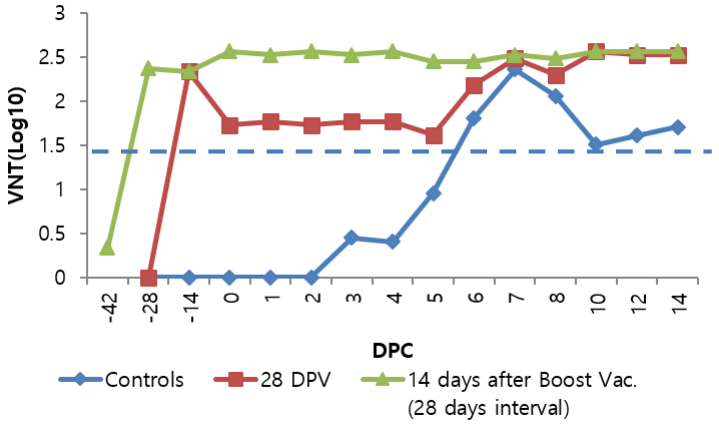
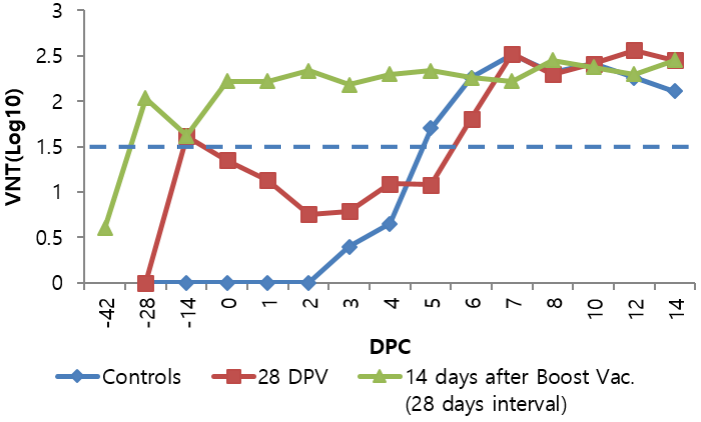


*** O 3039**

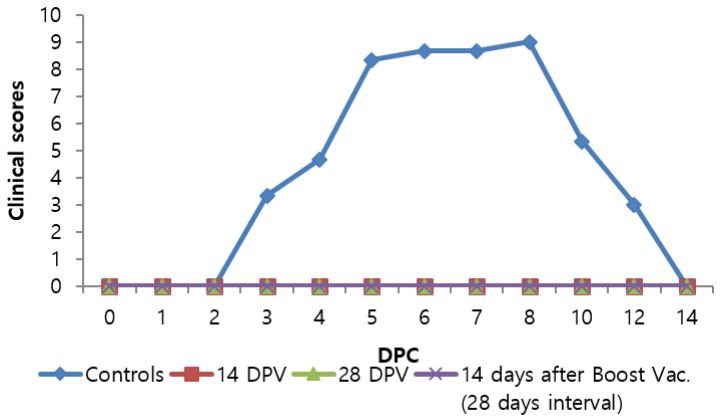
< Heterogenous virus** VNT >



**** O SKR/2014**

Efficacy of the **O SKR 7/2010** vaccine after challenging with Jincheon virus(O SKR/2014) in pigs

< Clinical scores >



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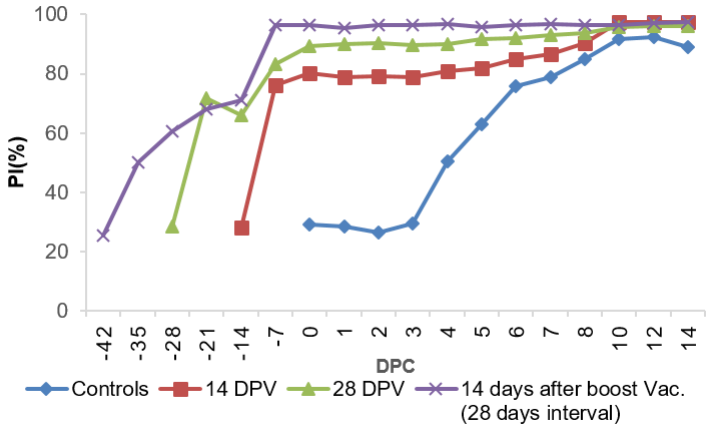

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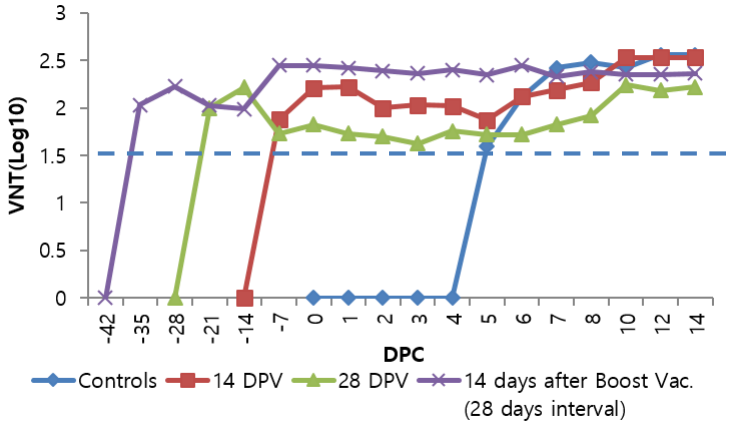

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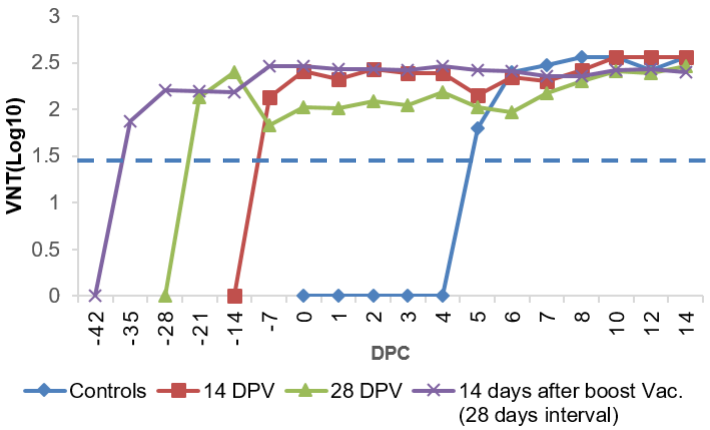
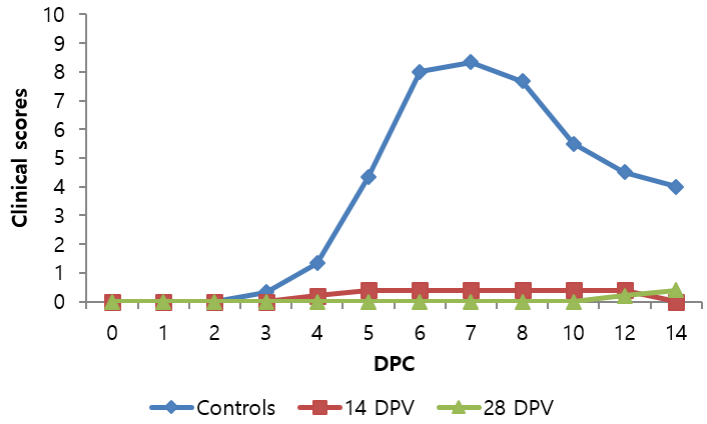


*** O SKR/2010**

**** O SKR/2014**

Efficacy of the **O1 Campos** vaccine after challenging with Jincheon virus(O SKR/2014) in pigs

< Clinical scores >



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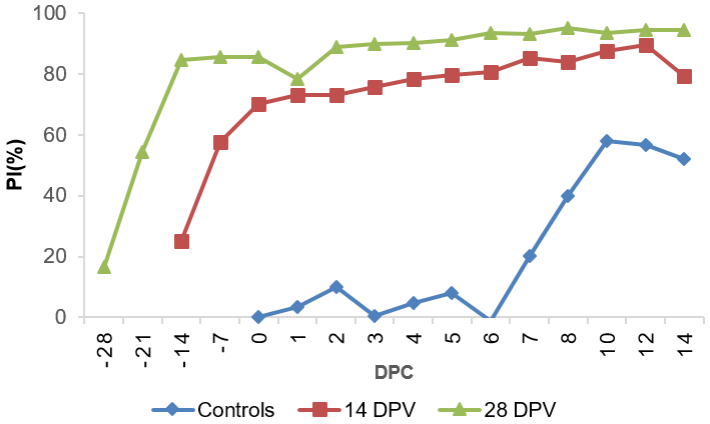

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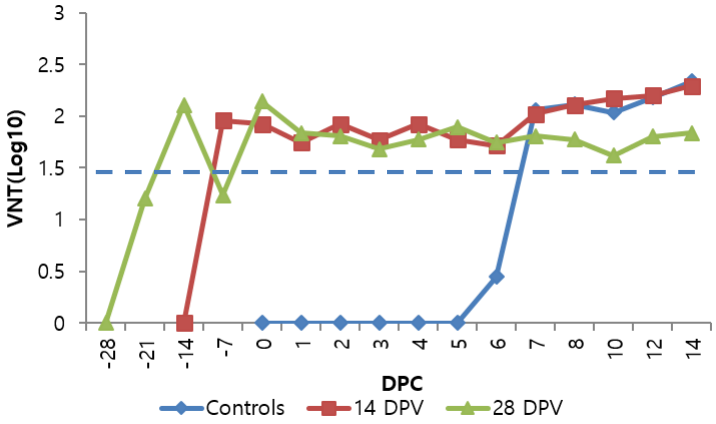
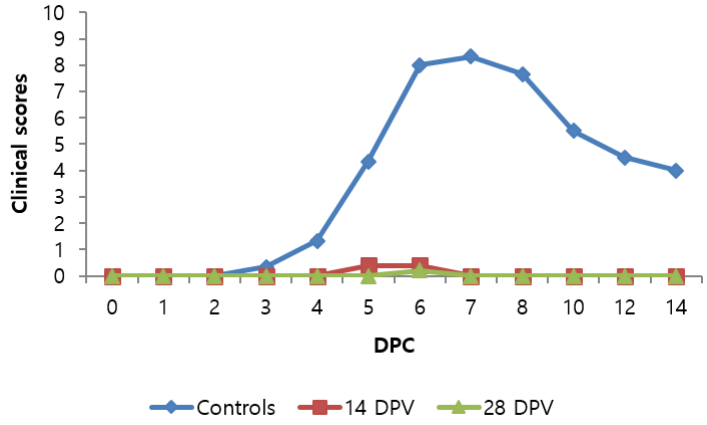


*** O SKR/2014**

Efficacy of the **O Primorsky 14** vaccine after challenging with Jincheon virus(O SKR/2014) in pigs

< Clinical scores >



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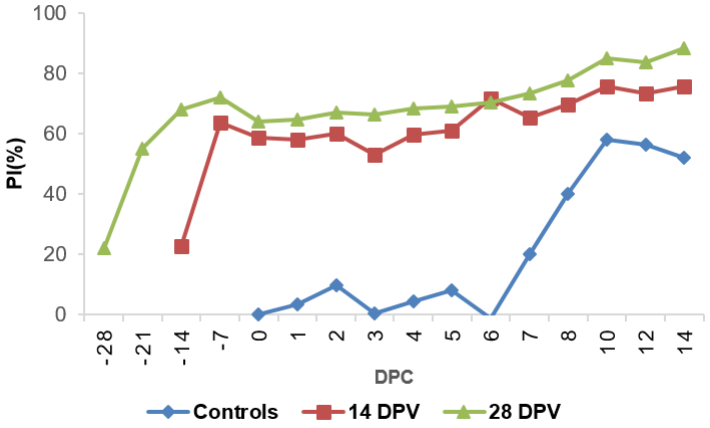

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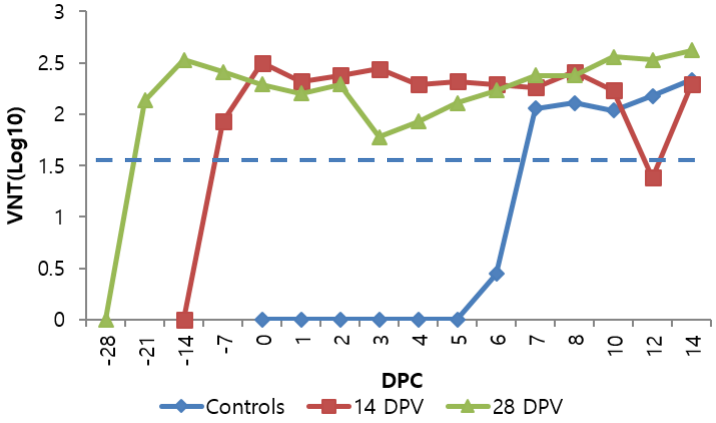
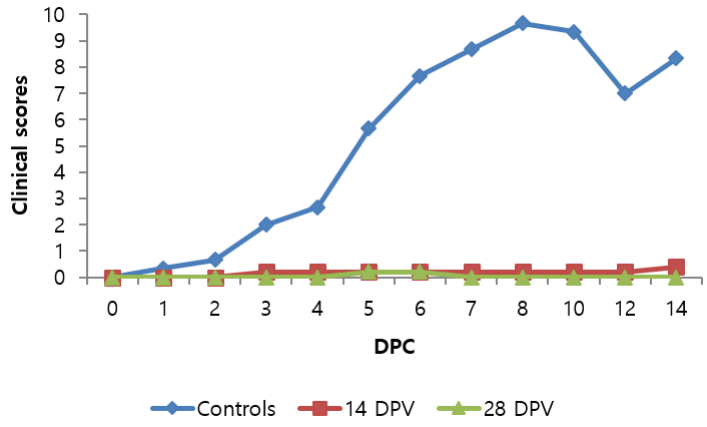


*** O SKR/2014**

Efficacy of the **O Taiwan97** vaccine after challenging with Jincheon virus(O SKR/2014) in pigs

< Clinical scores >



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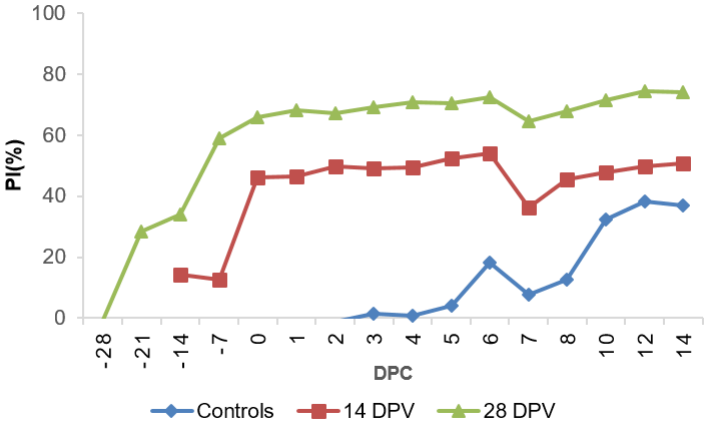

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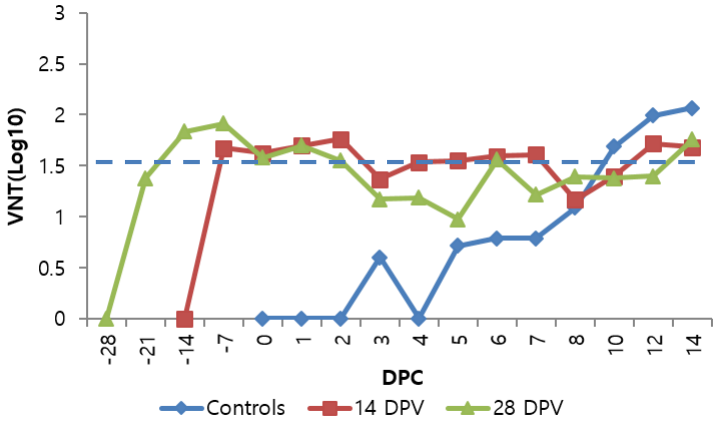


*** O SKR/2014**

Summary (1)

- Except the O 3039 monovalent vaccine, all vaccines provided proper protective immunity against the Jincheon strain (O SKR/2014, O/SEA/Mya-98) in pigs
- Protections against the Jincheon strain is mainly related with VNT titers to the Jincheon strain at the challenge time
  - The O SKR 7/2010 vaccine showed the best protection against the O SKR/2014 FMD challenge in the biosafety containment facility
  - But, the r1 value has approximate relation with the protection against the Jincheon strain

Vaccine strains	r1 value	Protection	Comment
O1 Manisa	0.10-0.30[a]	Full protection after 28 DPV	Formulated into one
O 3039	0.42-0.73[a]		
O 3039	0.42-0.73[a]	Weak protection	
O SKR 7/2010	0.92-1.00[a]	Full protection after 14 DPV	
O1 Campos	0.72-1.00[b]	Strong protection	
O Primorsky 14	0.41-0.73[c]	Strong protection	
O Taiwan97	0.06-0.6[c]	Strong protection	

Tested and reported by a: WRL, b: SENASA, c: ARRIAH.

FMD VACCINE FIELD TRIALS TO CHECK VACCINE EFFECTIVENESS

Pilot field trials of FMD vaccines in pigs

- Field test for antibody response
  - 3 farms
    - 1 (8 week-olds) or 2 vaccination(8 and 12 week-olds)

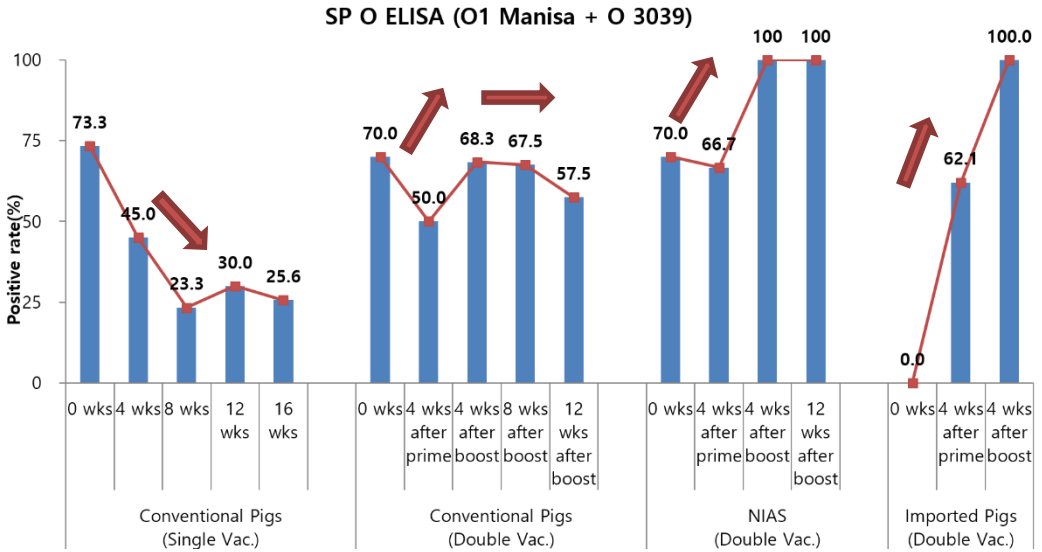
      or
    - 1 vaccination (8, 10, 12, or 14 week-olds)
  - Pigs
    - >20 heads/groups, 1 or 2 rounds
    - Bleeding: 0, 4, 8, 12, 16 weeks after vaccination
  - Check the serological aspects (ELISA, VNT)
    - Effects of maternally derived antibodies (MDAs)
    - Duration of immunity (DOI)
  - Check the formation of abnormal meat in slaughtering time

Field trial 1 in pig farms

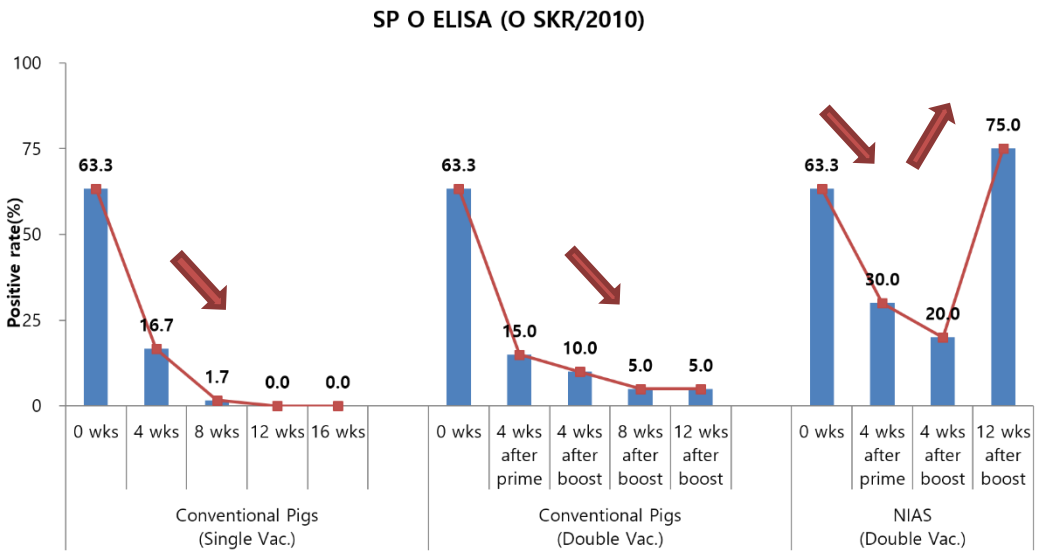
- Vaccines
  - 2 types of vaccines
    - The O1 Manisa + O 3039
    - The O SKR 7/2010 (originated from the outbreak in Andong at 2010)
- Farms
  - 3 types of farms
    - 3 Conventional pig farms: 20 pigs/farms
    - 1 National Institute of Animal Science (NIAS): 30 pigs
      - Livestock resource and quality control and research center of Korea
    - 1 imported pig farms (only in O1 Manisa + O 3039 trial): 29 pigs
- Study plan
  - Vaccination
    - Single vaccination at 8 week-olds or double vaccination at 8 and 12 week-olds
  - Bleeding
    - 0, 4, 8, 12, 16 weeks after vaccination

Changes of ELISA titer of vaccinated pigs with different vaccines

O1 Manisa + O 3039



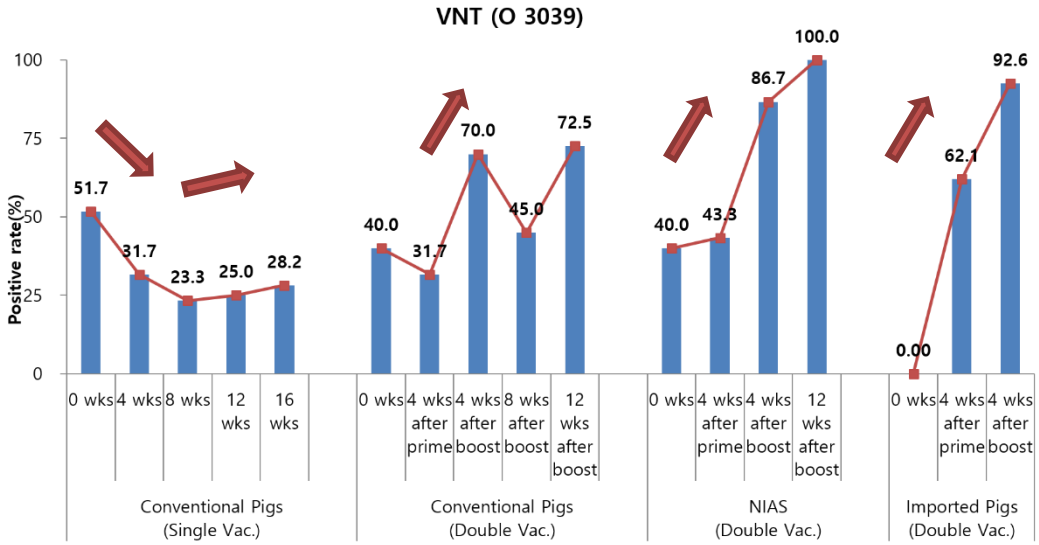
O SKR 7/2010



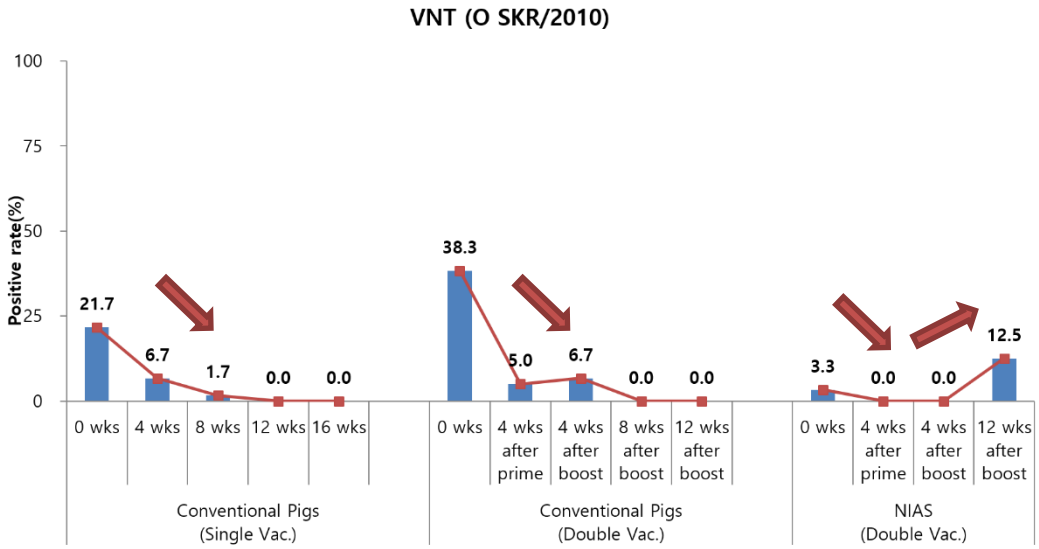
※ ELISA: O type SP ELISA (Prionics®), positive (≥50 PI(%))

Changes of VNT titer of vaccinated pigs with different vaccines

O1 Manisa + O 3039



O SKR 7/2010



※ VNT: homogenous virus, positive (≥1:32)

Results of field trial 1 in pig farms

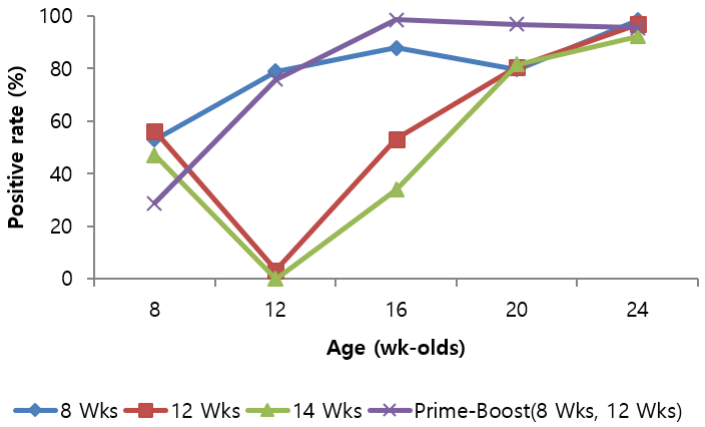
- The O1 Manisa + O 3039 vaccine
  - Private conventional pig farms
    - The positive ratio decreased with single vaccination, but the positive ratio increased and maintained to some extent with double vaccination
  - NIAS Pigs
    - The positive ratio increased with double vaccination
  - Imported Pigs
    - The positive ratio increased with double vaccination
- The O SKR 7/10 vaccine
  - Private conventional pig farms
    - The positive ratio decreased with single and double vaccination
  - NIAS Pigs
    - The positive ratio increased to very limited extent with double vaccination
- Overcome of O type MDA effects
  - Double vaccination of the O1 Manisa + O 3039 vaccine: **Yes**
  - Double vaccination of the O SKR 7/2010 vaccine: **No**

Field trial 2 in pigs farms

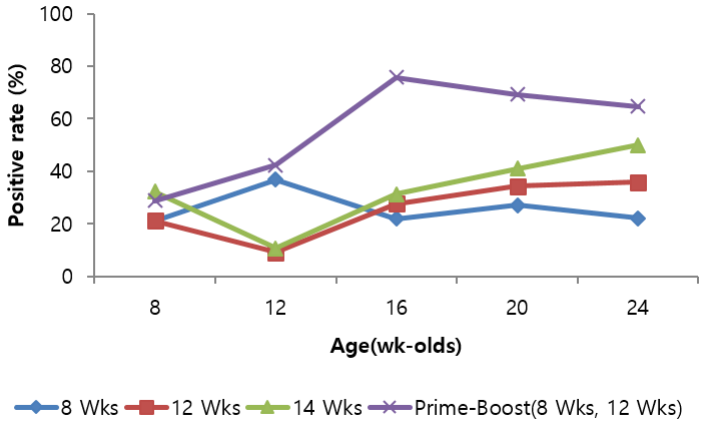
- Vaccines
  - 2 types of vaccines
    - The O1 Campos
    - The O Primorsky 14
- Farms
  - 3 Conventional pig farms
- Pigs: 22 pigs/groups
- Study plan
  - Vaccination
    - Single vaccination at 8, 12, or 14 week-olds
    - Double vaccination at 8 and 12 week-olds
  - Bleeding
    - 8, 12, 16, 20, and 24 week-olds

Changes of ELISA titer of vaccinated pigs with different vaccines

O1 Campos



O Primorsky 14

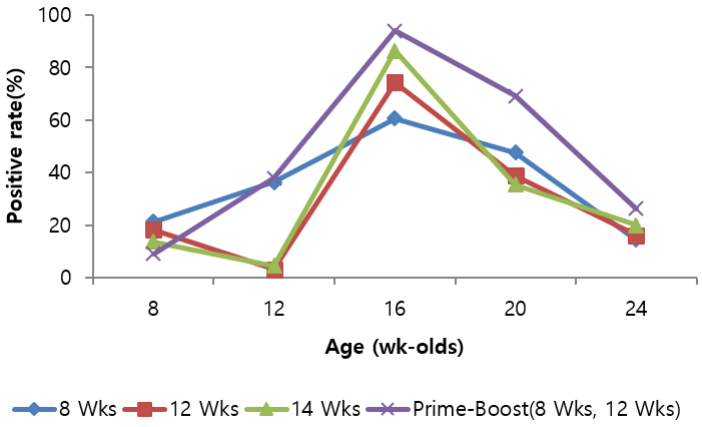


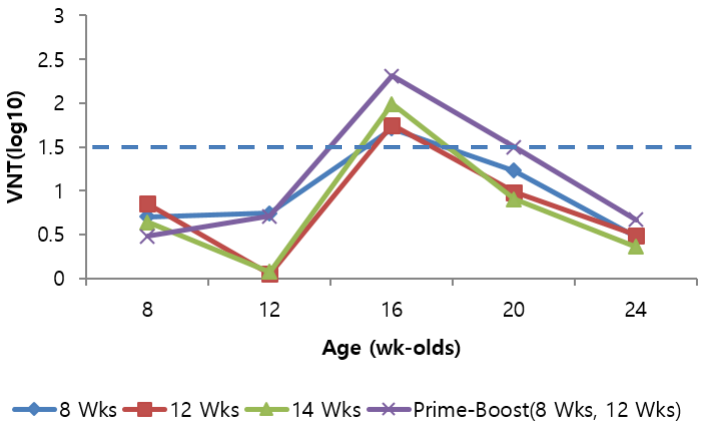
The heterologous effects of ELISA coated antigen (O1 Manisa)

※ ELISA: O type SP ELISA (Prionics®), positive (≥50 PI(%)).

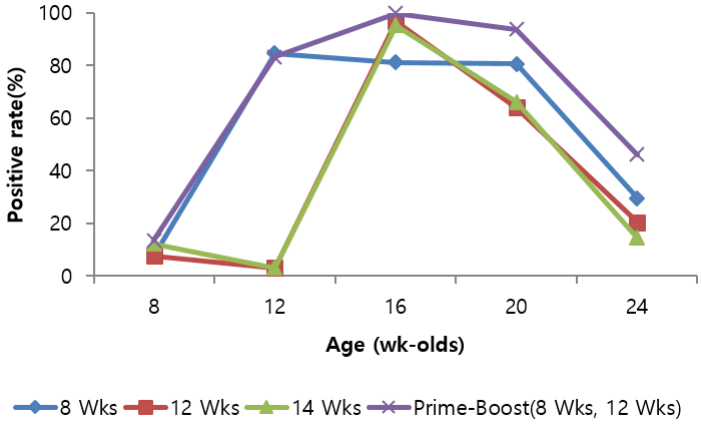
Changes of VNT titer of vaccinated pigs with different vaccines to heterogenous FMDV(O SKR/2014)

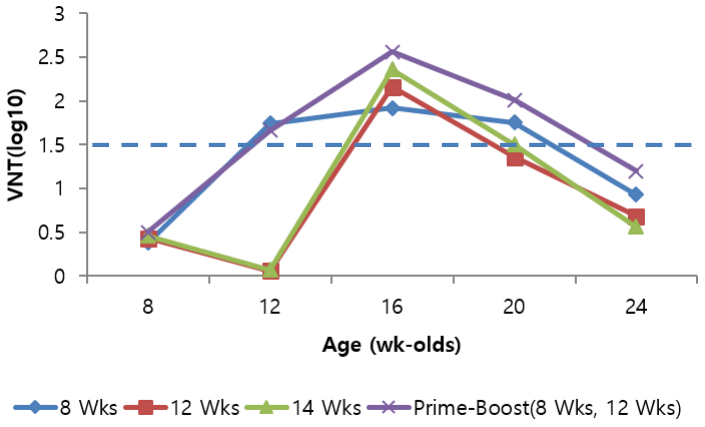
O1 Campos





O Primorsky 14

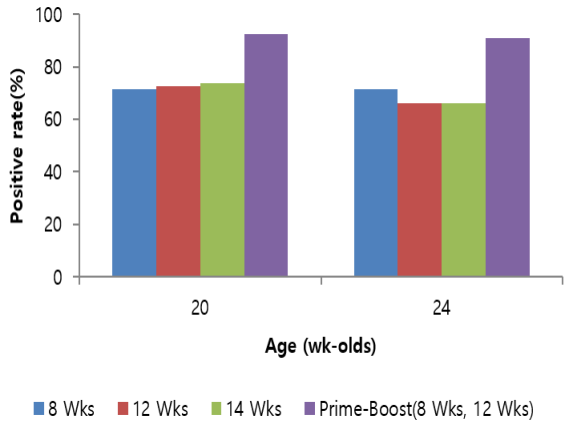


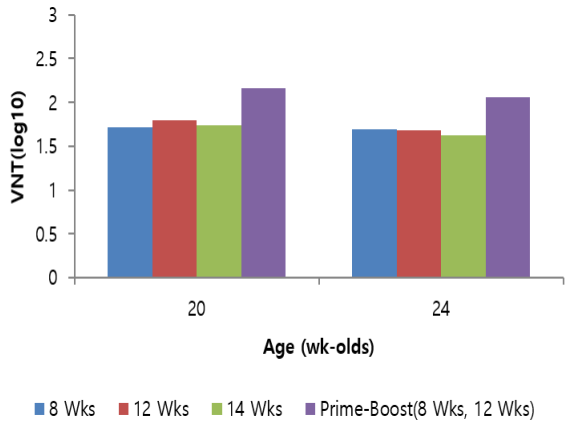


※ VNT: heterogenous virus(O SKR/2014), positive (≥1:32=1.5 log VNT titer).

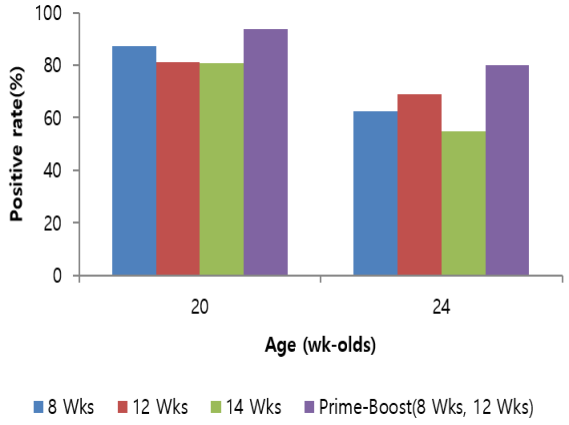
Changes of VNT titer of different vaccines to homogenous FMDV

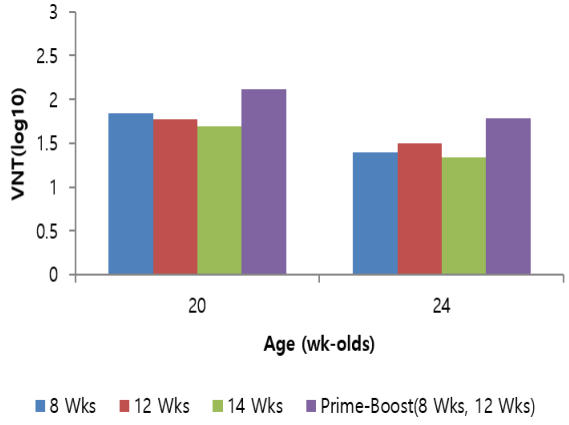
O1 Campos





O Primorsky 14





※ VNT: homogenous virus, positive (≥1:32)

The results of field trial 2 in pigs

- The serological results
  - The homogenous VNT results of the O1 Campos vaccine and the O Primorsky 14 vaccine indicated that both vaccines provided the proper immunity against each vaccine strain with single and double vaccination
  - O type SP ELISA(Prionics®) results showed that the O1 Campos vaccine showed better performance than the O Primorsky vaccine
  - The results of heterogenous VNT titers indicated that the O Primorsky vaccines showed better results than the O1 Campos vaccine
    - The antigenic closeness might affect the results of SP ELISA and Jincheon VNT titer of both vaccines
- Overcome of O type MDA effects
  - The O1 Campos vaccine and the O Primorsky 14 vaccine might overcome the vaccine blocking by O type MDA effects in recent situation

Summary (2)

- In pig vaccination, effects of MDA should be carefully considered before applying vaccination.
- Influencing factors of FMD vaccine performance in pigs
  - Vaccine quality
    - Antigen strain
    - Antigen payload
    - Adjuvant and other additions
  - Host species (cows, pigs)
  - Vaccination methods
    - Single vaccination or double vaccination
  - Maternally derived antibodies (MDAs)
  - Feeding and management
    - NIAS vs Private conventional pig farms

Conclusions

- The r1 value
  - The r1 value is only one factor for each vaccine efficacy among many other considerations
- The heterologous cross-protection challenge test
  - The results of the heterologous cross-protection challenge test could be properly applied only in FMD-free animals
- The pilot field trials in pigs
  - In the routine vaccination of pigs like the nationwide vaccination situation in South Korea, pilot field trials might need to be performed to estimate the effect of MDAs on serological performance of the vaccine
  - In the field trial, the O SKR7/10 vaccine induced poor immune responses which showed failure to overcome MDA, even though good results were shown in SPF pig challenge test and vaccine matching(r1 value: 0.92-1.00).
- The selection of FMD vaccines in pigs
  - Multifactorial events involved in vaccination should be considered

Thank you for listening!