

A Compendium of Shigatoxigenic *Escherichia coli*: Origins, Bacteriological and Clinical Data on the Serogroups, Serotypes and Untypeable Strains of *E. coli* Reported between 1980 and 2017, Excluding O157:H7

Karl A. Bettelheim, Paul N. Goldwater*

Adelaide Medical School, University of Adelaide, Adelaide, Australia

Email: *paul.goldwater@adelaide.edu.au, pgoldwater@gmail.com

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Abstract

The purpose of this paper was to create a compendium of serogroups, serotypes and untypeable strains of Shigatoxigenic/verotoxigenic (STEC/VTEC) *Escherichia coli*. The compendium includes the origins, bacteriological and clinical data on this important group of microbes. The collection of STEC/VTEC data extends from 1980 to 2017, and excludes STEC/VTEC O157:H7. A total of 499 papers were discovered and documented to create the compendium which includes all the serogroups and serotypes beginning with serogroup O1 through to serogroup O211 and includes O non-typeable strains and ill-defined strains including serotype O⁵⁴⁰⁷¹:H7. The paper summarises the findings of 8010 *E. coli* isolates and includes all details including source (human or animal), and clinical condition/disease, serogroup and serotypes, country of origin, year reported, and the author(s) with cited references. Some twenty clinical conditions were shown in association with 4320 serotypes/and untypeable strains. The compendium is a record of an important group of STEC/VTEC and should provide a useful resource for both researchers and clinicians.

Keywords

Shigatoxigenic *Escherichia coli*, Verotoxigenic *Escherichia coli*, STEC, VTEC, Human Disease, Animal Disease

1. Introduction

Specific non-O157 *E. coli* serotypes are associated with specific clinical disease

pictures or syndromes in both humans and animals. In humans clinical diseases may include non-life-threatening diarrhoea and vomiting and abdominal cramps or life-threatening clinical diseases such as septicaemia or more rarely, haemolytic uraemic syndrome. Other presentations include infections of the meninges, urinary tract and soft tissues and a variety of specific animal-associated infections. Also there is, in humans an association between cases of Sudden Infant Death Syndrome and specific serotypes of *E. coli* [1].

This paper was written as a compendium of STEC/VTEC serotypes and was designed to provide researchers with a unique referenced list of *E. coli* serotypes found in humans and animals with and without associated disease. The list is a gathering of all accessible literature published in English on serotypes and other isolates of STEC/VTEC between the years 1980 and 2017.

2. Methods

All available literature in English was searched using the terms, *Escherichia coli*, *E. coli* with the use of search engines including PubMed, Google Scholar, and Web of Science, and Current Contents Connect. The search included all papers published between 1980 and 2017 (up to 7 November 2017). All data on papers describing isolates of Shiga-toxin producing strains of non-O157 *E. coli* were collated and presented in tabular format to include serogroup, O and H serotype, the isolate's origin (including human, animal or environmental source, associated clinical condition (if any) and country of origin). The author(s) and specific reference is cited in each table. The diagnostic criteria for inclusion of Shiga-toxin producing *E. coli* were any assay that detected either or both Stx-1 or Stx-2 toxins or their respective genes. All papers in which these tests were not used were excluded from the compendium.

3. Results

A total of 499 papers on STEC were discovered through the search. As can be seen from the tables STEC are represented in every known serogroup and serotype of *E. coli* however, certain serotypes are more commonly encountered than others. For example, there are six serogroups that are over-represented and the Centers for Disease Control and Prevention (CDC) recognise these as responsible for causing 70% of cases of non-O157 STEC-associated human disease. The serogroups include O26, O45, O103, O111, O121, and O145. It should be emphasised that serogroup or serotype does not accurately correlate with clinical manifestations of disease. Type of disease and its level of severity depend on numerous other virulence factors of the STEC and also on host factors (e.g. age, gender).

Table 1 shows in chronological order these 499 *E. coli* publications with a reference in brief. **Table 2** records all the serogroups and serotypes beginning with serogroup O1 through to serogroup O211 and includes O non-typeable strains and ill-defined strains including serotype O⁵⁴⁰⁷¹:H7. The table summarises the

findings of 8010 *E. coli* isolates and includes all details as alluded to in the Method. **Table 2** lists the serogroups and serotypes, the origin, disease and country of origin, year reported, the author(s) with a brief reference. Twenty clinical conditions (listed below) are shown in association with these 8010 serotypes/and untypeable strains. The abbreviations used are listed below.

AP	Abdominal pain
ARF	Acute renal failure
BD	Bloody diarrhoea
BE	Bowel oedema
Cell	Cellulitis
D	Diarrhoea
Dys	Dysentery
EC	Enterocolitis
HA	Haemolytic anaemia
HC	Haemorrhagic colitis
HUS	Haemolytic uraemic syndrome
Inf	Infection
NE	Necrotizing enteritis
No D	No diarrhoea
Sept	Septicaemia
SHS	Swollen head syndrome
SIDS	Sudden infant death syndrome
TCP	Thrombocytopenia
UC	Ulcerative colitis
H	Healthy/No symptoms

Table 1. Shows in chronological order these 500 *E. coli* publications with a reference in brief.

Link to Table 1

https://scotchsa-my.sharepoint.com/:x/g/personal/vetchw_scotch_sa_edu_au/EY4oFNOocGINuuTToPshB1QB_2uH5-XjssmoTDO_csvpg?e=fff7gl

Table 2. Records all the serogroups and serotypes beginning with serogroup O1 through to serogroup O211 and includes O non-typeable strains and ill-defined strains including serotype O"54071":H7. The table summarises the findings of 8010 *E. coli* isolates and includes the origin, disease and country of origin, year reported, the author(s) with a brief reference (twenty clinical conditions are shown in association with these 6346 serotypes and untypeable strains).

Link to Table 2

https://scotchsa-my.sharepoint.com/:x/g/personal/vetchw_scotch_sa_edu_au/EfClcSYtc8RDgI5CPDeNVkkBijcbb51AfA1ldvV7_OWWHQ?e=is4Yoa

Table 3 provides a numerical summary of each serotype in relation to its association with sources (human or animal), and clinical condition reported. **Table 4** demonstrates a selection of serotypes of *E. coli* to show wide host specificity and ability to infect and cause diseases. Although sheep are reportedly infected by all

these strains, seemingly there is an inability to cause disease in ovine species. **Table 5** provides an overview of the important serogroup O103. The search revealed 286 isolates of this particular serogroup. The table records the serogroup's first reported isolation in 1993 and demonstrates its clinical and host spectrum along with country of origin.

Table 3. Is a numerical summary of each serotype in relation to its association with source (human or animal), and clinical condition reported.

Link to Table 3

https://scotchsa-my.sharepoint.com/:x/g/personal/vetchw_scoth_sa_edu_au/EZyajW7w9CpMkKXv_KoZK1oBSBpHcpIw89oUAcO7Mmk_Pw?rttime=SQfWBF5I10g

Table 4. Demonstrates a selection of serotypes of *E. coli* to show wide host specificity and ability to infect and cause disease.

Serotype	Human Diseased	Human Healthy	Human?	Cattle Diseased	Cattle Healthy	Cattle?	Beef	Sheep Healthy	Sheep meat	Other	Total	Sheep Diseased
O5:H-	23	0	1	6	16	0	2	14	4	10	76	0
O26:H-	53	2	7	2	7	1	0	1	0	6	79	0
O26:H11	126	0	10	6	38	2	6	7	0	13	208	0
O111H-	89	2	5	6	19	1	2	0	0	0	124	0
O111:H2	6	0	0	0	1	0	0	0	0	0	7	0
O111:H8	25	0	2	4	6	0	1	0	0	0	38	0
O113:H-	4	3	1	1	11	1	3	0	0	2	26	0
O113:H4	11	5	1	0	14	1	10	2	0	10	54	0
O113:H21	29	0	6	10	41	1	18	0	0	23	128	0
O128:H-	10	0	1	0	1	1	1	9	0	5	28	0
O128:H2	32	8	1	0	2	0	5	15	0	17	80	0
O174:H8	5	6	0	1	3	0	2	9	1	12	39	0
O174:H21	21	3	3	0	30	1	13	1	1	12	85	0

Table 5. Examines the serogroup O103 in relation to animal host spectrum, disease potential and country of origin.

Link to Table 5

https://scotchsa-my.sharepoint.com/:x/g/personal/vetchw_scoth_sa_edu_au/EehRV4Rf159DnaCEsTVnf7gBjf7z-VtCD8HfXhkumnz6DQ?e=I71rA7

4. Discussion

This study shows that *E. coli* demonstrates the same type of variability as the related genus of *Salmonella*, where The Kauffman and White table based on somatic "O" and flagellar "H" antigens characterises the diverse serotypes of *Salmonella*. They show a variability with regard to host specificity and pathogenicity.

This compendium of non-O157 serotypes of STEC was designed to provide researchers and clinicians with an extensive resource and help provide under-

standing of the importance of this evolving group of potential and recognized pathogens.

5. Conclusion

The paper provides a glimpse into the evolution of STEC/VTEC. It gives an indication that future outbreaks of disease with new combinations of O and H serotypes and virulence factors will inevitably occur and continue to surprise.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References¹

- [1] Pearce, J.L., Bettelheim, K.A., Luke, R.K.J. and Goldwater, P.N. (2010) Serotypes of *Escherichia coli* in Sudden Infant Death Syndrome. *Journal of Applied Microbiology*, **108**, 731-735. <https://doi.org/10.1111/j.1365-2672.2009.04473.x>

¹All other references are contained within the tables of data.